BALANCE AND FALL RISK ASSESSMENT IN ADULT HABITUAL YOGA PRACTITIONERS

by

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Background: Postural control in a functioning human is highly complex and dynamic. The main functional goals, postural orientation and postural equilibrium, decline as a person ages. As a result, unintentional falls occur frequently in ostensibly normal older adults and the falls are one of the leading causes of fatal and nonfatal injuries in individuals over the age of 55 years. A hypothesized fall prevention mechanism that has become more available and popular in the United States is the practice of yoga. The purpose of this study was to investigate whether or not the habitual practice of yoga alters balance measures and associated fall risks. If so, then the practice of yoga is justified as a preventative measure for unintentional falls in adults.

Methods: Forty, apparently healthy individuals between the ages of 55-70 years of age were recruited to complete the study. Twenty-one of the subjects were recruited based on their participation in yoga for at least eight weeks for a minimum of three times per week. The remaining nineteen subjects were recruited based on their lack of enrollment in yoga classes, and placed in the control group. Each subject completed a survey of health history (including fall history and the Falls Self-Efficacy Scale-International) and yoga participation characteristics to determine subject eligibility. Upon arrival to the testing site, subject's height and weight was measured. Next, subjects were asked daily activity pattern questions based on the Global Physical Activity Questionnaire to determine an estimated daily metabolic equivalent above basal metabolic rate. Balance measures were then taken through use of the Balance Evaluation Systems Test (BESTest). Once all testing was complete, subjects received a review of their performance measures. Data was analyzed using a 2-tailed t-test with a priori alpha set at $p < 0.05$ for each dependent variable. A univariate analysis of variance was performed to determine any effect of yoga participation duration, types of yoga practiced, and age on balance performance and the FES-I total score.

Results: The BESTest total score of the yoga practitioners (94.66% ± 3.54) was significantly higher than that of the control group (89.43% ± 4.06, $P < 0.001$). Specifically, the sections of the BESTest that the yoga practitioners had significantly higher scores than the control group were biomechanical constraints (14 ± 0.89, 13 ± 0.88), transitions/anticipatory postural control (17.24 ± 1.22, 16.11 ± 1.20), sensory orientation (14.81 ± 0.40, 13.89 ± 1.10), and stability in gate (19.71 ± 0.90, 18.32 ± 1.42). This difference persisted though the group activity levels, as measured by the GPAQ, were not statistically different between groups ($P > 0.05$). The FES-I total score and the number of claimed falls in the past twelve months were not significantly different between groups, mainly due to the younger age of the subjects (61.12±4.15 years and 59.60±2.99 years for the yoga group and the control group, respectively) in comparison to high fall-risk seniors (>70 years old.) No significant relationship was determined between the duration of habitual of yoga, types of yoga practiced, and age on balance performance and the FES-I total score

Conclusion: This study shows that there is a significantly improved balance score for individuals, between 55 and 70 years old, who habitually practice yoga, as determined by the Balance Evaluation Systems Test.

Table of Contents

Chapter 1

INTRODUCTION

Among adults age 55 and older, falls are one of the leading causes of fatal and nonfatal injuries (1). In 2013, 2.5 million nonfatal falls among older adults were treated in emergency departments and the direct medical costs of falls were $34 billion in the United States alone (1, 2). About 25,500 older adults died from unintentional fall injuries in 2013 (1). Therefore, there is no question that methods to lower the frequency of falls and subsequent costs are potentially of great benefit to society. A hypothesized fall prevention mechanism that has become more available and popular in the United States is the practice of yoga. Yoga is an ancient discipline that is designed to bring balance and health to physical, mental, emotional, and spiritual dimensions of the practitioner. The intent of this study was to explore how the habitual practice of yoga in adults 55 years and older effects a variety of balance measures when compared to healthy controls of the same age.

The two main functional goals of postural behavior are postural orientation and postural equilibrium (3). Postural orientation integrates the alignment of the trunk and head with "respect to gravity, support surfaces, the visual surroundings, and internal references" (3). Postural equilibrium is the coordination of movement strategies to "stabilize the center of body mass during both self-initiated and externally triggered disturbances of stability" (3). In order to adequately assess the success of one's ability to achieve these goals, there are six resources that must be tested to determine any inadequacies. These resources that take into account the context in which the individual resides includes; sensory strategies (sensory integration and sensory rewriting), movement strategies (reactive, anticipatory, and voluntary), biomechanical constraints (degrees of freedom, strength, and limits of stability), cognitive processing (attention and learning), control of dynamics (gait and proactive), and orientation in space (perception, gravity, surfaces, vision, and verticality) (3). Postural control is context-dependent and requires functional integration of each resource to appropriately achieve static and dynamic stability.

It is well known that scores in each of these resources decline with age. The effect of age on postural control is quite small, but a small decrease in postural stability due to age alone is the increased probability in the elderly of developing specific pathologies, which lead to accelerated degeneration in neural and/or musculoskeletal systems (4). One example of a small decrease in postural control is the hypersensitivity to changes in postural orientation that can cause a shift in movement patterns. Older individuals tend to use the hip strategy as well as the stepping strategy to maintain postural stability (3). These strategies are intended for recovery from large perturbations, yet older adult hypersensitivity to postural changes cause a larger than necessary recovery method. This is just one example of what can occur with balance as a result of aging. Other examples of inaccuracy frequently seen in older adults include latency to postural response, motor learning, biomechanical constraints, inaccurate detection of head and body position and motion, adaptive weighting to sensory inputs, internal maps of postural stability limits, and integration of sensory information with motor performance. Every individual's deficiencies are highly complex and context dependent. Therefore, postural orientation measurements must test a plethora of circumstances to possibly detect balance deficits.

Yoga, like many other exercises, has been shown to improve the rate of decline in postural stability and other pathologies that tend to increase with age. A review done by Tiffany Field in 2010 on the effects of yoga in clinical research helps us have an overview of all the benefits of yoga that have been studied. Psychological symptoms and disorders, pain syndromes, cardiovascular conditions, autoimmune conditions, immune conditions, pregnancy conditions, physiological effects, and physical effects are all seen to improve with yoga practice (5). Physiologically, yoga is designed to stretch and tone the muscles of the body and to keep the spine and joints flexible (5), but it is obvious that yoga benefits are multifaceted and target a number of factors that make seniors vulnerable to experiencing falls (6) and developing pathology that may cause this vulnerability.

There are a number of postulations that could explain why yoga elicits balance improvements that were explained in the previous section, but I believe the most promising school of thought has yet to be researched. There is a possibility that repeated passive stretching, which occurs in yoga often, results in chronic reductions in reflex sensitivity. Essentially, there is a reduction in the activity of the large-diameter afferents, resulting from the reduced sensitivity of the muscle spindles to repeated stress (7), and this allows older adults to desensitize their muscle spindle degrees of freedom prior to a reflex. Individuals participating in yoga will experience diminishing degrees of freedom while yoga practitioners will maintain their limits of stability, much like younger adults. This is an area of research that can extend from the present study if postural control differences are recorded between habitual yoga practitioners and the healthy control subjects.

Statement of the Problem

The problem of the study was to examine differences in biomechanical constraints, stability limits, postural responses, anticipatory postural adjustments, sensory orientation, stability in gait, and fear of falling scores in habitual adult yoga practitioners and healthy adults.

Purpose of the Study

The purpose of the study is to investigate whether or not the habitual practice of yoga alters balance measures and associated fall risks. If so, then the practice of yoga is justified as a preventative measure for unintentional falls in adults.

Need for the Study

Among adults age 55 and older, falls are one of the leading causes of fatal and nonfatal injuries (1). In 2013, 2.5 million nonfatal falls among older adults were treated in emergency departments and the direct medical costs of falls were $34 billion in the United States alone (1, 2). About 25,500 older adults died from unintentional fall injuries in 2013(1). Therefore, there is no question that fall prevention is a top priority for the aging population. A hypothesized fall prevention mechanism that has become more available and popular in the United States is the habitual practice of yoga.

Yoga is an ancient discipline that is designed to bring balance and health to physical, mental, emotional, and spiritual dimensions of the practitioner. In 2004, a population-based telephone survey (n=2055) resulted in 3.8% of respondents reporting the use of yoga in the previous year, and cited wellness (64%) and specific health conditions (48%)

as the motivation for doing yoga (8). The physical demand of yoga, in comparison to endurance activities such as running and cycling, is low due to the low-intensity and low-impact nature of the exercise. For this reason, yoga is considered to be more accessible by adults than more intense exercise. While not as intense as fast-paced exercise, yoga as an intervention has been shown to be as effective as or better than intense exercise at improving a variety of health-related outcome measures (9).

These improvements are possibly seen for a number of reasons. One of which would be due to the increased vagal activity and the resulting decreased cortisol levels that is seen in massage therapy, which yoga is considered a form of self-massage (5). The increased vagal activity down-regulates the hypothalamic pituitary-adrenal axis and the sympathetic nervous system to reduce a state of hypervigilence often seen with aging (9). Another postulation for explaining why yoga could cause these improvements is that the improvements in physical measures directly relate to the yoga intervention because yoga practice involves training on poses very similar to balance outcome measures (10). Essentially, the mind-body awareness, the correct alignment instruction, endurance, and hand-eye coordination practice improve these measures. A final reason that could explain improvements seen with yoga intervention is a change in reflex sensitivity. Repeated passive stretching, which occurs often in yoga, reduces the activity of the large-diameter afferents, and result in reduced sensitivity of the muscle spindles to repeated stretch (7). This could inhibit the reflex hypersensitivity often seen with aging adults.

This study addresses the habitual practice of yoga in adults as a prevention mechanism for unintentional falls. A cross-sectional balance study of habitual yoga practitioners, to the author's knowledge, has never been done. There have been a plethora of studies that have shown yoga interventions as a health aid in a wide variety of situations, yet very few look at the long-term benefits of the practice. Therefore, as yoga gains popularity in Western culture, it is important to know the health outcomes of such an exercise to determine its merit in the health community. A specific aim of this study is to determine if habitual (≥ 8 weeks) adult yoga practitioners differ from healthy controls in balance measures that can predict risk of falling. This information will allow the scientific community to address the preventative effect yoga has on unintentional falls in the adult community.

Hypotheses

The study was designed to test the following null hypotheses:

1. There is no significant difference in balance performance as determined by the total BESTest score between habitual adult yoga practitioners and healthy adults matched for age.
    a. There is no significant difference in biomechanical constraints as determined by Section I of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.
    b. There is no significant difference in stability limits as determined by Section II of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.
    c. There is no significant difference in transitions/anticipatory postural control as determined by Section III of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.

d. There is no significant difference in reactive postural response as determined by Section IV of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.

e. There is no significant difference in sensory orientation as determined by Section V of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.

f. There is no significant difference in stability in gait as determined by Section VI of the BESTest between habitual adult yoga practitioners and healthy adults matched for age.

2. There is no significant difference in daily metabolic expenditure as determined by GPAQ between habitual adult yoga practitioners and healthy adults.
3. There is no significant difference in fear of falling scores, as determined by the Falls Self-Efficacy Scale International, and number of self-reported unintentional falls in the past twelve months between habitual adult yoga practitioners and healthy adults.
4. Within the yoga practitioner group, there is no significant difference in subject's BESTest total score and FES-I score between duration of habitual yoga participation, the types of yoga practiced, and a subject's age.

Delimitations

This study was delimited to the following:

1. Approximately twenty women and men, ages 55 years and older, currently attending a yoga studio or practicing within their home on a regular basis, practiced yoga a minimum of eight weeks at least three times a week, were free of any

diagnosed neuromuscular or balance disease, who were considered to be habitual adult yoga practitioners.

2. Approximately twenty women and men, ages 55 years and older, were free of any diagnosed neuromuscular or balance disease, not currently enrolled in a yoga program, who were considered to be healthy control adults.
3. All subjects were screened for daily activity levels to determine non-yoga activity that could alter balance scores.
4. All subjects underwent a balance assessment through the use of the Balance Evaluation – Systems Test (BESTest). These scores were used to determine balance performance and to assess the subject's risk of falling.
5. Six measures of balance control systems; (a) biomechanical constraints, (b) stability limits/verticality, (c) transitions/anticipatory, (d) reactive, (e) sensory orientation, and (f) stability in gait. Test measures were obtained through examiner scoring.
6. A data collection period throughout the fall and spring semester of the 2015-2016 school year.

<u>Limitations</u>

The results from this investigation were interpreted considering the following limitations:

1. Subjects who participated in this study were volunteers who complied with the requirements of this investigation rather than a random sample. As a result, the generalizability of the study's results was delimited to the tested sample.
2. Data were collected under controlled conditions at the Indiana University Exercise Science Laboratory in Bloomington, Indiana, DePauw University in Greencastle, Indiana, Indiana University – Purdue University Indianapolis in Indianapolis, IN,

Quest for Balance Studio in Crawfordsville, IN, and The Villas at Ridgefield Farm Clubhouse in Danville, KY.

3. Daily activities of the subjects were not controlled, but they were self reported.
4. Although subjects were requested to refrain from ingesting caffeine, alcohol, and any type of medication that may alter balance or cause dizziness during the 24 hours prior to testing, surveillance of subjects during this time did not occur and therefore, occasional variance from this could not be controlled.
5. The discipline of yoga does not maintain homogeneity. The yogic background of the habitual adult yoga practitioners may vary to large degrees from subject to subject. As such, the investigator collected information on the type of yoga performed on a regular basis for each experimental subject.

Assumptions

The basic assumptions of this study were:

1. The motivational level of both experimental and control groups participating in this study were uniformly high.
2. Subjects refrained from balance altering substances (caffeine, alcohol, medications) for a minimum of 24 hours prior to arriving for testing.
3. The subjects answered questions on the Global Physical Activity Questionnaire and the health/yoga history survey honestly and to the best of their abilities.

Definition of Terms

The following terms are defined to clarify their use in the study:

Aging Adults/Older. Men and women 55 years and older.

Anticipatory Postural Adjustments. This system includes tasks that require an active movement of the body's center of mass in anticipation of a postural transition from one body position to another (11).

Biomechanical Constraints. Biomechanical constraints for standing balance include the quality of the base of foot support, geometric postural alignment, functional ankle and hip strength for standing, and ability to rise from the floor to a standing position (11).

Habitual. An act that has been repeated three or more times a week for at least eight weeks. The habituality of a subject's yoga practice will be studied as a continuum to determine the affect of duration on balance measures.

Healthy. In relation to this study, individuals without diagnosed balance or neurological disorders were considered healthy.

Postural Responses. Reactive postural responses include both in-place and compensatory stepping responses to an external perturbation induced by the examiner's hands using the unique "push and release" technique. To induce an automatic postural response with the subject's feet in place, the tester pushes isometrically against either the front or back of the patient's shoulders until either the toes or heels just begin to raise without changing the initial position of the body's center of mass over the feet before suddenly letting go of the push (11).

Stability Limits. This system includes items for an internal representation of how far the body can move over its base of support before changing the support or losing balance, as well as an internal perception of postural vertical (11).

Sensory Orientation. This system identifies any increase in body sway during stance associated with altering visual or surface somatosensory information for control of standing balance (11).

Stability in Gait. This system includes evaluation of balance during gait and when balance is challenged during gait by changing gait speed, by head rotations, by pivot turns, and by stepping over obstacles (11).

Yoga. An ancient discipline that is designed to bring balance and health to physical, mental, emotional, and spiritual dimensions of the practitioner through use of the eight-limbed path that forms the structural framework of the practice. The eight limbs consist of the following; (a) yama (universal morality), (b) niyama (personal observances), (c) asanas (body postures), (d) pranayama (breathing exercises), (e) pratyahara (control of the senses), (f) dharana (cultivating inner perceptual awareness), (g) dhyana (meditation), (h) Samadhi (union with the divine). This study is most interested in the affect of asanas on balance measures in older adults.

Strength. The ability of a muscle to produce force.

Flexibility. In relation to this study, flexibility is static joint and muscle range of motion and the biomechanical ability to adequately move the body in response to a perturbation.

Chapter 2

REVIEW OF THE RELATED LITERATURE

The literature related to changes in balance seen with age and how these changes may be altered with yoga is reported in this chapter. For organizational purposes, the literature is presented under the following topics: (a) Balance; (b) Aging and Balance; (c) Benefits of Exercise on Aging and Balance; (d) Benefits of Yoga; and (f) Summary.

Balance

There are two different schools of thought on postural responses to disequilibrium, otherwise known as balance. Originally, activation of the reflex pathways in response to sensory receptors was thought to control postural responses to perturbation (4). This school of thought ruminates information flow as unidirectional from sensory receptors to motor effects (4). In other words, it was once thought that sensory stimulus alone shapes the motor response to perturbation, but this is incorrect. The information flow from sensory receptors to motor effects only adequately describes changes in limb and head position from perturbation in reduced animal preparations (4). Therefore, more details are required to fully understand postural control in humans.

The more recent, widely accepted, school of thought considers postural control in a functioning human as highly complex and dynamic rather than simply a summation of static reflexes. Postural control requires many underlying physiological systems that alter a person's ability to interact with the environment appropriately (3). The two main functional goals of postural behavior are postural orientation and postural equilibrium (3).

By delving into these two goals, researchers and clinicians are able to systematically analyze the particular balance disorders affecting each individual.

To adequately achieve the functional goals of postural orientation and equilibrium for postural control, there are six resources required as described by Horack in 2006 (3). The remainder of this section will be dedicated to describing and understanding each of these important resources that may be the cause of balance disorders and the increased incidence of falls in the elderly, as shown in Figure I below.

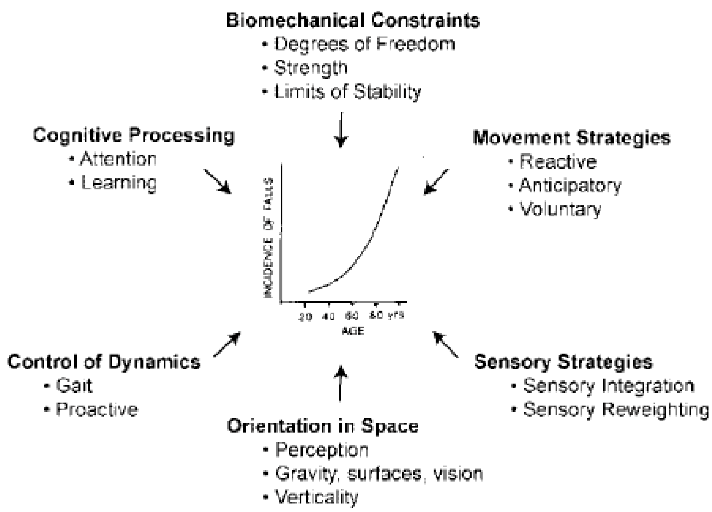


Figure I. Resources Required for Postural Stability and Orientation (3)

Sensory Strategies. The first resource being investigated is the sensory process in balance control. In the first half of the 19th century, sensory strategies were being tested and the Romberg Sign was discovered (12). The revealed phenomena was described by individuals that had profound loss of proprioception or individuals with uncompensated unilateral or bilateral vestibular dysfunction tended to fall if vision was eliminated by closing the eyes (12). At that point, scientists decided that more than one system controlled balance. Postural orientation involves the active alignment of the trunk and head with respect to gravity, support surfaces, the visual surroundings and internal references and this requires more than one system of sensory orientation. Therefore, orientation information is provided by the somatosensory (proprioceptive, cutaneous, and joint), vestibular, and visual systems for optimal balance (3, 12, 13). Yet, the sensory system is more complex than sensory input because there is also sensory reweighting that occurs for optimal balance.

The components of the sensory strategy of the body begins with the detection of peripheral sensory stimuli, and is followed by central selection and weighting of sensory information (4). Each orientation input is given a relative weight "dependent on the goals of the movement task and the environmental context" (3). While there are multiple sensory inputs available at any given time, the central nervous system generally relies on only one sense at a time for sensory orientation (13). The system in which the central nervous system relies is dependent on the context and environment the individual is presently in. For example, healthy adults in a well-lit environment with a firm base of support, will for the majority rely on somatosensory inputs that relay information from the feet in contact with the support surface (3, 13). The other inputs in this context are 10% vision and 20% vestibular, leaving 70% for the somatosensory inputs (3). However, when the environment changes, so do the weighted reliance on the multiple sensory inputs. In other words, the functional ranges of the sensory systems overlap, and allow for partial compensation for deficits or distortions (12). Instability can occur when there is an inappropriate interaction among the sensory inputs where the central nervous system is not adaptable or able to re-weight the sensory information if reduced or inaccurate information is acquired from the sensory inputs (3, 13). The resulting instability can result in unintentional falls, which will be addressed further in the aging and balance section of this literature review.

Movement Strategies. Postural equilibrium involves the coordination of movement strategies to stabilize the center of body mass during both self-initiated and externally triggered disturbances of stability. There are motor processes in balance control that coordinate the actions of the body into "discrete synergies" that control sway and center of mass maintenance within the base of support (13). These motor processes are selected depending on the characteristics of the external postural displacement and on the individual's expectations, goals, and prior experience (3). As shown in Figure 1, there are anticipatory adjustments, voluntary movement, and reactive aspects to the movement strategies utilized in postural control.

Anticipatory postural adjustments, prior to voluntary limb movement, "serve to maintain postural stability by compensating for destabilizing forces associated with moving a limb" (3). The anticipatory adjustments are one example of how coordination of postural movement patterns is a complex process. The five major components of movement strategies are the coordination of postural movement patterns, the latency to postural response, the scaling the postural response to the stimulus, the motor learning of the individual, and the biomechanics of the individual (4). Each of the five components of movement strategies must combine appropriately for successful coordination of movement and postural control.

When a perturbation occurs, the movement strategies of the body must synchronize to return the individual to equilibrium. There are three movement patterns that are seen when an individual is perturbed while standing. The first is referred to as the ankle strategy and is described as a time where the body moves at the ankle as a flexible inverted pendulum in order to appropriately maintain balance for small amounts of sway when standing on a firm surface (3). The second movement pattern during upright perturbation recovery is the hip strategy. The body exerts torque at the hips to quickly move the body's center of mass when the individual is standing on a narrow or compliant surface that does not allow adequate ankle torque or when the center of mass must be moved quickly (3). The third movement pattern is to take a step to recover equilibrium. The step strategy is quite common during gait or when keeping the feet in place is not imperative, but the individual must attempt to return the center of mass to the initial position by exerting angle torque first (3). Each of the three movement patterns is the summation of the discrete synergies required for coordinated movement, especially post-perturbation while standing.

Biomechanical Constraints. So far, we have looked at the sensory and movement processes of postural control to determine how the body uses these resources for appropriate control, but biomechanical constraints can alter how these processes function. The size and quality of the base of support, the feet, are the most important biomechanical constraints on balance (3). Limitations in size, strength, range, pain or control of the feet will affect balance (3). Controlling the body center of mass with respect to its base of support is essential for postural control. The relationship between center of mass and base of support determines the limit of stability, represented by the cone of stability for each individual, that is, "the area over which an individual can move their center of mass and maintain equilibrium without changing the base of support" (3). Our bodies use the cone of stability information to determine if we can maintain equilibrium in a certain situation, or if we must put a movement strategy into action to gain control of posture.

Orientation in Space. There is rarely a time in a healthy individual's daily activity that they consciously think about their body's orientation in space. We don't say to ourselves, "I need to move my left foot one inch to the right to make sure I orient my center of mass correctly while standing on this surface." However, unconsciously we do think about these things. The ability to orient body parts with respect to gravity, the support surface, visual surroundings, and internal references automatically happens in healthy adults (3). In essence, how vertically an individual stands is determined by the central nervous system's perception of that verticality. For example, there may be multiple neural representations of verticality that are independent of the proprioception in an individual attempting to align the body in space without vision. If there is an error in the internal representation of verticality, the individual will be tilted in the upright position (3). Therefore, appropriate orientation in space requires perception, gravity, surface, vision, and verticality to each be taken into account properly. Without proper summation of each resource, inappropriate orientation occurs.

Control of Dynamics. Changing from one posture to another and gait requires the body to move the center of mass to the outside the base of foot support. The movement requires complex control of a moving body center of mass and proactivity to prevent the body center of mass from moving too far outside the base of foot support. The information required about the position of the center of mass must be derived from peripheral sensory information (4). Proper control of dynamics requires peripheral sensory information about; a) "motion of the body with respect to the support surface and motion of body segments with respect to each other from the somatosensory system," b) "motion of the body with respect to extrapersonal space from the visual system," and c) linear and angular acceleration of the head from the vestibular system" (4). Each source of information must be properly functioning to have appropriate control of dynamic movement such as walking or running.

Cognitive Processing. Postural control is not simply a physical task for motor control and the central nervous system. Instead, there are many cognitive resources that play a role in postural control. First, there is the attention aspect of postural control. When an individual is standing quietly, there are increased reaction times due to the cognitive processing required (3). The reaction times increase further with an increase in difficulty of the postural tasks (3). Therefore, the health of an individual's cognition is important in appropriate postural control.

Summary. Each of these six resources for postural control takes into account the context in which the individual resides. Reactions to perturbations on sturdy surfaces indoors are drastically different in each category when compared to perturbations on unstable surfaces outdoors. As a result of the differences in responses, postural control is context-dependent and requires functional integration of each resource, and when this isn't achieved a fall will likely occur.

Aging and Balance

Postural control in a functioning human is highly complex and dynamic. Balance requires many underlying physiological systems to be functioning properly to allow a person to interact with the environment appropriately. The main functional goals, postural orientation and postural equilibrium, decline as a person ages. As a result, unintentional falls occur frequently in ostensibly normal older adults. Advancing age has been associated with muscle weakness, reduced cutaneous sensation, decreased nerve conduction velocity, diminished proprioception, and reduction in efficient cortico-motor neurons (14), which can all contribute to the increase unintentional falls.

First, we must define a fall. "A fall is an event which results in a person coming to rest unintentionally on the ground or other lower level, not as the result of a major intrinsic event (such as a stroke or syncope) or overwhelming hazard" (15). Researchers have estimated that one-third to one-half of the population aged 65 years and older fall each year even when a balance disorder is seemingly not present (4). Furthermore, it is widely recognized that older people with balance disorders suffer from multiple impairments. An individual's function depends on the type of impairment and the strategies used to accomplish stability for a particular task to compensate for the impairment (3). Therefore, any model of the effect of age on postural control must account both for the increased instability found in the majority of elderly subjects, and the increased variability in postural control in the elderly as a group (4).

One model to describe the effect of age on postural control is often defined as prebyastasis. Belal and Gorig coined the term in 1986 to describe the general postural control problem in elderly as involving many systems rather than a local lesion in any one area of the vestibular system (16). Prebyastasis describes instability as an inevitable "aging" effect that results from widespread degeneration of the musculoskeletal, neuromuscular, and sensory systems (4). According to Belal and Gorig's original study, they classified prebyastasis into two clinical types titled constant and episodic (16). The constant prebyastasis was classified as disequilibrium continuing over a long period of time, while episodic prebyastasis was attacks of dizziness separated by symptom-free intervals (16). They found that slightly more females than males displayed these prebyastasis symptoms and the onset occurred between 65 and 75 years of age (16). This global effect of aging seen could be due to the use of generalized balance measures, such as increased movement of body sway. There is a chance that the older population is unaware of diseases that could alter their balance and they could consider themselves free of musculoskeletal and neurologic abnormalities (4). These generalized measures to show the global effect of aging cannot localize the source of the deficit and the clinician or researcher will have no indication to the causes of the instability in a given elderly individual. Therefore, another model that divides postural control into a set of functional components based on neurophysiology of postural control is needed to describe the effect of age on postural control.

Another model that describes the effect of age on postural control is considered to be a systems approach. The effect of age on postural control is quite small, but a small decrease in postural stability due to age alone is the increased probability in the elderly of developing specific pathologies, which lead to accelerated degeneration in neural and/or musculoskeletal systems (4). Individuality is key in assessing postural control in the elderly. Each individual is unique in the probability with which a given pathology will develop. As a result, the pattern of postural instability and the type of falls will also be unique to each individual (4). Regardless of any underlying medical condition elderly persons may suffer, impairments in stability will be manifested in reduced functioning in one or more of the sensori-motor systems upon which postural control depends (15). In a study done by Lord, Clark, and Webster in 1991, they found that specific variables were able to discriminate between subjects who experienced multiple falls within a year of testing and subjects who experienced no falls or only one fall (15). These variables were; proprioception in the lower limbs, visual contrast sensitivity, ankle dorsiflexion strength, reaction time, and sway with the eyes closed (15). The following paragraphs will further delve into the multiple mechanisms of the systems approach to aging that could play a role in these variables of fall prediction.

Motor Components. Coordination of postural movement patterns, latency to postural response, motor learning, and the biomechanics of an individual's body all play a role in the effect of aging on the motor components of postural control. Beginning with coordination of postural movement patterns, the most used pattern of correction after perturbation changes with age. As mentioned in the Balance section of this literature review, there are three patterns of correction of anterior-posterior sway or perturbation. The patterns include, the ankle strategy, the hip strategy, and taking a step to recover equilibrium. Unfortunately, elderly individuals at risk of falling and individuals that have a fear of falling tend to use the stepping and hip strategies more than an individual with a low risk of falling and who uses the ankle strategy to maintain postural stability (3). Individuals can influence which strategy is engaged based on intention, experience, and expectations, and as a result, the fear of falling can cause this shift in movement pattern selection. The need to take a step or use the hip strategy can be detrimental when an elderly individual has an increased variability in timing relations among the muscles within a particular strategy and exhibit significant increases in antagonist muscle postural response, which has been observed in a large proportion of supposedly normal elderly subjects (4). The hypersensitivity to changes in postural orientation can cause the shift in movement patterns that place the individual at a higher risk of falling.

Another motor component change to postural control that occurs frequently in the elderly population is the latency to postural response. Postural responses are initiated in response to unexpected, externally produced perturbation in balance or in anticipation of voluntary movements. They act to prevent losses of balance, which could result from the destabilizing forces associated with self-initiated body movements (4). In everyday life, perturbation direction and amplitude must be encoded and the appropriate response must be elected and initiated within a very short time (4). Aging has been known to display deficits in stimulus encoding, central processing, and response initiation, but this could be due to an increased incidence of pathological conditions (4). Pathologies that slow nerve conduction time in afferent or efferent pathways, pathologies that slow central processing down, and pathologies that slow voluntary movements could delay postural responses.

Automatic responses to disequilibrium depend not only on sensory information, but also on expectation, prior experience, and practice that all come from motor learning. Unfortunately, it is well documented that motor learning processes are affected by aging. Disequilibrium and gait ataxia in some elderly individuals are due to deficits in motor learning. There is a strong relationship between the "quality of gait as measured by stride length and walking speed and the incidence of falls" (17). Individuals with weak lower extremities and poor balance take small steps and walk slowly and this becomes a learned motor task (17). Likewise, over response to perturbations due to subtle cerebellar signs is not uncommon in the elderly population (4). As a result, an elderly individual develops new automatic responses that could result in an increased incidence of unintentional falls.

The final motor component to be addressed is biomechanics. Patterns of neural activity from the central nervous system must be implemented by the body's musculoskeletal system. Therefore, postural stability is constrained by the body's biomechanics (4). Changes in muscle strength and flexibility, being prone to orthopedic pathologies, and extrapyramidal dysfunction can result in inadequate joint flexibility and mobility for recovery from perturbations and a shift in the position of the center of gravity in the body (4). Yet, one of the most important factors of biomechanical aging is strength.

Strength is a major factor in balance. Muscle mass declines between .5% and 1% annually in men and women over 60 years of age and strength declines faster than muscle mass, stemming from age related decreases in the amount of excitable muscle tissue (17, 18). This can greatly alter an individual's ability to complete daily tasks and recover from a perturbation, because there is a chance that strength is a prerequisite neuromuscular capability that underlies both balance and gait. For example, ankle strength is imperative for proper vertical alignment throughout any stance that requires putting weight on the feet. A major biomechanical strategy for neutralizing back-wards displacement is organized use of the head, trunk, and arms to develop countermoment (17). Ankle dorsiflexion is a key component of the synergy as it stabilizes the foot while stopping further backwards displacement, lifts the forefoot, thereby creating a fulcrum based at the heel and produces anteriorly directed forces which reestablish vertical alignment (17). The ankle strength of fallers is much weaker than controls and an increase in speed elicits even more decrements in dorsiflexion (17). Twitch prolongation could also alter an older individual's ability to combat disequilibrium. Lower frequencies of nerve impulses are required to attain a given muscle tension with twitch prolongation, but this slowing causes there to be a reduced capacity for rapid production of force in response to protective reflexes (18). Yet, it is unknown if these age differences reflect a failure of descending drive from the motor cortex or the result of atrophied muscles(18). Additionally, dynamic and static movement could be very different in terms of the source of balance deficit and could be different for each individual.

With decrements in motor components as we age, there are obvious consequences. The coordination of postural movement patterns become less coordinated with age, there is latency to postural response, motor learning is altered, and the biomechanics of an older individual's body does not facilitate balance and postural control. Yet, the motor components of postural control are not the only aspects of the body that affected by age. Sensory components of the body modify as we age, too.

Sensory Components. Pathology in peripheral or central sensory systems can affect sensory components of postural control. The accurate detection of head and body position and motion, adaptive weighting to sensory inputs, internal maps of postural stability limits, and integration of sensory information with motor performance are all sensory components that alter balance capacities of aging individuals.

In order to accurately detect the position and motion of the head and body, the sensory components of postural control must be properly functioning. A widely regarded normal consequence of aging that could alter the proper detection of position is the loss of sensitivity in the peripheral sensory systems. The loss of sensitivity can include somatosensory loss reflected in reduced vibration sense at the ankle, reduced joint position sense at the ankles, visual impairments (loss of contrast sensitivity for fine details, sensitivity to flickering objects, and impaired pursuit eye movements), and vestibular degeneration (reduced numbers of vestibular hair cells, Scarpa's ganglion cells, and eigth nerve fibers) (4). However, each of the "normal consequences of aging" could be caused by pathological conditions, such as cervical spondylosis and vestibular loss, which the individual is unaware of.

Addressed in the "Balance" section of the present literature review, there is adaptive weighting of sensory inputs depending on their relative usefulness as orientation references for the nervous system. Information about the position and the movement of the body must be integrated in the central nervous system to produce an accurate representation of the movement of the center of gravity (4). With aging, there is a "slowing of the ability to rapidly and accurately select and weight sensory inputs assumed to rely on central mechanisms" (4). The decrease in speed and accuracy of inputs greatly alters how the individual is able to interpret and respond to his or her surroundings and center of gravity.

Additionally, evidence indicates that some elderly individuals may perceive their stability limits to be smaller than they actually are and their construction of internal maps of postural stability limits is inappropriate. For example, when some elderly subjects are asked to sway forward and backward to their stability limits they produce almost no center of gravity movement and mainly use the hip method to "sway" (4). A young subject is usually able to produce 10 degrees of forward and 5 degrees of backward movement (4) and is indicative of the young subject being comfortable with a larger stability limit when compared to an elderly subject. With a smaller internal map of postural stability limits, an elderly individual may react to very small changes in center of gravity as if they were completely perturbed out of balance. The inaccurate sensitivity may cause overcorrection and possibly an unintentional fall.

The final sensory component that can affect postural control is the integration of sensory information with motor performance, and there are a number of problems that could alter the integration. Peripheral sensory deficits may affect which movement strategies are selected (4) and the affect is shown through the selection of the hip and step method pervasiveness in elderly subjects. Another problem could be the control of dynamics. Older people who are prone to falls tend to have larger than normal lateral excursions of the center of mass and more irregular lateral foot placements to control the dynamics of normal movement (3). Cognitive processing is also required for proper integration of sensory information with motor performance. Individuals who have limited cognitive processing due to neurological impairments may use more of their available cognitive processing to control posture and may fall from "insufficient cognitive processing to control posture while occupied with a secondary cognitive task" (3).

Overall, there is a multicomponent nature of disequilibrium in the elderly. As adults age, the likelihood of acquiring pathology which affects important components of postural control increases and older individuals are highly likely to have abnormalities in more than one component of postural control (4). The declines in functional postural components contribute to instability and falls with aging. Fortunately, preventative strategies have been researched to minimize the risk of falling without compromising the mobility and functional independence of the older adults.

Prevention. Due to the multifactorial nature of disequilibrium in the elderly, there is a need for a multifaceted approach to fall prevention (19). There are changes that need to occur in the home and changes in the daily routine of the individual to minimize the risk of falling. Each of the prevention techniques were developed due to the motor and sensory components that alter with age.

The majority of falls among the elderly occur in their own home. The causes of the falls in an individual's own home are known as environmental factors that affect the risk of falling. Desforges, et al. suggested that an individual can prevent falls by making sure lighting is accessible and appropriate, floors are stable and clear of small objects, stairs are lit sufficiently and bilateral handrails are used, grab bars are accessible for the toilet, tub, and shower in the bathroom, entrances are free of ice and wet leaves, and spills cleaned up promptly (19). When an elderly individual can maintain these aspects of their home, there will most likely be a decrease in the amount of falls that occur within the home.

Another preventative technique to reduce the risk of falling in the elderly is the adoption of an exercise program. The loss of strength in the elderly can be combatted through high-resistance exercise training programs that are effective in improving both muscle size and voluntary strength (18). The exercise program may give the older adult significant gains in walking ability and reduction in the incidence of bone fractures caused by falls (18). Furthermore, the US Department of Health and Human Services recommends that older adults get at least 150 minutes per week of moderate-intensity or 75 minutes per week of vigorous-intensity aerobic physical activity, muscle-strengthening activities twice per week, and balance training three or more days per week (20). These preventative measures will be discussed further in the following section of the review of the related literature.

Benefits of Exercise on Aging and Balance

As mentioned briefly in the previous section, exercise can reduce the effects of aging within the body. We have now established that as an individual ages and becomes less active, we see decrements in adequate postural control, and increased likelihood of acquiring pathology that affects the important functions of the body. The following paragraphs will describe the benefits of exercise seen in the aging population, the benefits of exercise seen in postural control, and the specific benefits seen as a result of different types of exercise.

We know that the changes in postural control with age are far from the only physiological changes seen within the body. There are numerous negative effects of aging that can greatly alter the body's ability to function. Cardiovascular function is one of these negative effects. Fortunately, low- to moderate-intensity activities performed daily have been shown to have some long-term health benefits and lower the risk of cardiovascular disease in the elderly population (21). Regular aerobic physical activity increases exercise capacity, increases cardiovascular functional capacity, and plays a role in both primary and secondary prevention of cardiovascular disease (21).

Other problems seen with aging are diabetes and obesity. Regular exercise has been shown to control blood lipid abnormalities, diabetes, and obesity through beneficial changes in hemodynamic, hormonal, metabolic, neurological, and respiratory function as exercise capacity increases (21). An example of beneficial respiratory function change is maximum ventilatory oxygen uptake. Between the ages of 20 and 80, maximum ventilatory oxygen uptake drops 5-15% per decade, but a lifetime of dynamic exercise maintains an individual's oxygen uptake at a level higher than that expected for any given age (21).

Another change that can occur with aging is a decrease in psychological functioning. Elderly individuals are known to report symptoms such as anxiety and depression regularly enough to be prescribed medications that could alter other functions of the body. Exercise has been found to increase psychological functioning. Tests have shown that older adults who regularly exercise are better adjusted to their surroundings, perform better on tests of cognitive functioning, exhibit reduced cardiovascular response to stress, and report fewer symptoms of anxiety and depression (21). Additionally, regular physical activity improves self-confidence and self-esteem and reduces some type "A" behaviors (21). As a result, exercising throughout an individual's lifetime can be extremely beneficial for more than just postural control.

Balance and postural control is an aspect of aging that can benefit from exercise. As postural control constitutes a limiting factor for many daily activities and a variety of physical exercises, training of the highly adaptable postural control can directly influence performance in those activities (14). Exercise has been shown to decrease the number of falls, the probability that a fall will result in an injury, and the probability of falling (22). Possibly, balance training induces adaptations in all of the sensory systems assisting in postural control, such as vestibular, visual, and somatosensory as well as in the motor systems controlling muscular output (14). Even in the elderly population, neural control of balance can be retrained and rehabilitated in subjects with impaired reflex function due to spinal level cortical plasticity adaptations (14). Additionally, exercise has been shown to decrease the response frequency of antagonist muscles and increase the response frequency of the trunk flexor muscles (23). This suggests that sensorimotor integration could be enhanced through exercise, serving to activate the trunk flexor muscles with greater frequency and enhanced ability to select reliable sensory inputs for postural control (23). All of these enhancements seen with exercise training will aid in proper postural control and reduce the risk of falling.

While developing and maintaining aerobic endurance, joint flexibility, and muscle strength is known to be important as people age, estimations state that only 50% of all persons who initiate an exercise program will continue the habit for more than six months (21). The inherent risks of exercise, including, but not limited to, sudden cardiac death, falls and joint injuries, are extremely rare (21). Yet, people still choose to drop out of exercise programs and forgo the benefits.

Although a high percentage of individuals will drop out of an exercise program within six months of initiating the program, many people do continue the program and reap the benefits. An important aspect of these benefits is that the benefit of exercise is specific to the type of training (24). The following paragraphs will explain some of the benefits seem with different types of exercise.

The first exercise is resistance training. Many older individuals are apprehensive to begin a resistance training program due to risk of injury when handling weights. Yet, resistance training is both safe and beneficial in improving flexibility and quality of life in the elderly. This form of exercise has effects on maintenance of strength, muscle mass, bone mineral density, functional capacity, and prevention and/or rehabilitation of musculoskeletal problems (21). Therefore, the benefits outweigh the costs for resistance exercise in the elderly.

The next exercise is swimming. It has been shown that habitual swimmers have shorter movement time in eye-hand coordination (24). This could be due to muscular strength or some neural pathways might be enhanced in the repetitive upper limb movements during swimming and thus, improve eye-hand coordination (24). Swimming is also an aerobic exercise that, as mentioned above, can improve cardiovascular function, diabetes and obesity.

Another exercise important for postural control is balance training. This comprises of static and dynamic postural stabilization exercise that could have small to large effects on balance (25). These exercises use props, such as the BOSU ball, to create difficult balance maneuvers for the exerciser. It has been shown that a training period of 11-12 weeks produce the largest effects on both overall performance as well as for more specific measures of static steady-state balance (25). However, this type of training is not as approachable as many other forms of exercise due to the highly personalized aspect of this type of training and the requirement for numerous types of equipment.

The final type of exercise that will be reviewed in this section is T'ai Chi Chuan (T'ai Chi). T'ai Chi is known as meditation in motion that has seven therapeutic elements. These elements include; 1) continuous movement, performed slowly, 2) small to large degrees of motion, 3) knee flexion and weight shifting, 4) straight and extended head and trunk, 5) combined rotation of head, trunk, and extremities, 6) asymmetrical diagonal arm and leg movements about the waist, and 7) unilateral weight bearing with constant shifting (26). This low-stress, low-intensity, low-impact exercise has been shown to improve a plethora of aspects of individual practitioners. A few of these benefits are; less postural sway, better postural control, improved motor control, physical fitness, dynamic balance, pain reduction, improved aerobic capacity, blood pressure reduction, improved quality of life, stress reduction, improved sleep quality, increased strength, better knee joint proprioceptive acuity, faster reaction times, better control of leaning trajectory, shorter movement time in eye-hand coordination, and improves balance in complex conditions (24, 27-29). One possible explanation for simply the improved eye-hand coordination is that T'ai Chi emphasized that the gaze should follow the hand, thereby enhancing eye-hand coordination (24). T'ai Chi is similar to yoga, because in the practice of yoga each posture in the practice is given a specific gaze point that requires attention to eye coordination. Therefore, these benefits may also be seen in the practice of yoga.

One important factor to recognize when looking at exercise in the elderly is when the individual started practicing the exercise. A study done on physical sport activity showed that even if an elderly individual has not been practicing a physical sport activity their entire lives, individuals who had begun a physical sport activity late in life performed the same in posutrographic tests (30). Therefore, it is important for an elderly individual to start exercising regardless of their age. Finally, another important factor to recognize is that all subjects do not respond equally well to a specific training program (31). Each person reacts differently and will have different underlying issues that may relate to balance. Human subject unpredictability is imperative to understand prior to comparing subjects from any discipline.

Benefits of Yoga

The word yoga comes from Sanskrit, and means to yoke or to join together. The physical yoga postures were found in the Yoga Sutras apparently written in 3000 BC by the yoga guru, Patajali. There are many types of yoga practices, but yoga typically combines stretching exercises and different poses with deep diaphragmatic breathing and meditation thought to increase oxygen flow to the brain. Physiologically, yoga is designed to stretch and tone the muscles of the body and to keep the spine and joints flexible (5).

Yoga is typically practiced with bare feet on a mat. A series of poses that are called asanas are performed slowly and sequentially, concentrating each movement on the deep abdominal breathing that accompanies each movement. Even the movements between poses are just as important as maintaining a final posture. Depending on the teaching style of the class, many poses are held for four to five breaths. Popular teaching styles today include Hatha, Ashtanga, Vinyasa, Iyengar, and Bikram, and each have distinguishing features (5). Hatha (meaning sun/moon) in practice is a relaxing, restorative form of yoga. Yet, sometimes Hatha is used as an overarching term for all forms of yoga. Ashtanga is a strenuous series of poses sometimes referred to as power yoga that requires breath control and vigorous control of movement. Vinyasa is a moderately strenuous series of poses that are linked by a one-breath, one-movement philosophy. Iyengar focuses on holding poses and strenuous positions such as headstands to emphasize the development of strength. Bikram is a set series of postures practiced in a high temperature room that encourages a drishti, or gaze, at one's own eyes in the mirror throughout the practice.

While the present study focuses on balance in older adults, as mentioned in other sections of the review of literature, there are numerous factors that play a role in the postural control of an older adult. Fortunately, the benefits of yoga are multifaceted and target a number of the same factors that make seniors vulnerable to experiencing falls (6). The following review of conditions affected by yoga in recent research is predominately based on a review of literature written by Tiffany Field in 2010 (5).

Psychological symptoms and disorders are affected by the practice of yoga. Studies have shown enhanced mindfulness following yoga (32, 33) and reduced job stress following yoga in the workplace (34) and in fire stations with firefighters (35). Anxiety can also be affected by yoga. One study showed that yoga elicited a decrease in stress, anxiety, fatigue, and depression as well as increased well-being and vigor (36). Yet, these affects of yoga do not always require many weeks of practicing yoga. Immediate positive effects of yoga (post-one session) have also been noted on anxiety (37). Yoga is also effective for alleviating depression (38) One study that looked at two months of vinyasa yoga practice and found that yoga led to decreased depression (39). Furthermore, changes in brain waves (increased alpha waves) and decreased cortisol levels are noted during yoga postures (40), both of which could affect the psychological system of the body. The final psychological symptom studied that could be altered by yoga is sleep. In a chronic insomnia sample of subjects, yoga led to improvements on virtually every sleep measure; sleep efficiency, total sleep time, sleep onset latency, number of awakenings, and sleep quality measures based on sleep-wake diaries (41). Yoga also reduced sleep disturbances in a geriatric sample after 6 months of yoga practice where there were shorter latencies to sleep and a significant increase in the total number of sleep hours and in the feeling of being rested in the morning (42). Increasing deep sleep (restorative, quiet sleep) may reduce pain syndromes via a reduction in, for example, substance P that is known to cause pain (43). Reductions in psychological symptoms and disorders could allow older adults to reduce their reliance on medications that may cause postural control side effects that increase the incidence of unintentional falls.

Other conditions that have been recently researched in regards to the affect of yoga are different pain syndromes. Low back pain is extremely prevalent in older adults and after 12 weeks of yoga, back pain was reduced and back-related function was superior in the yoga group as compared to the therapeutic exercise (44). Another study reported less analgesic use and less opiate use to combat low back pain after a yoga intervention (45). Furthermore, a yoga group was able to reduce pain intensity by 64%, reduce functional disability by 77%, and reduce pain medication usage by 88% after weekly yoga sessions for 16 weeks (46). Headaches are another pain syndrome that could be affected by yoga practice. One study showed that after 3 months of weekly yoga sessions, the intensity and frequency of headache pain ratings, the anxiety and depression scores and the medication use were lower in the yoga group versus the self-care group (47). Yoga has been shown to be beneficial in the pain syndrome of osteoarthritis as well. After once weekly yoga sessions for 8 weeks in adults with osteoarthritis of the hands, the yoga group, compared to a no therapy group, had less pain during activity, less tenderness of the joints and greater range of motion in their fingers (48). Similar results were found with osteoarthritis of the knee being treated by yoga (49). Finally, rheumatoid arthritis patients can see improvements after a yoga intervention. Adults with rheumatoid arthritis were given a bi-weekly Iyengar yoga program for 6 weeks and significant improvements were noted in pain, pain disability and related measures of depression, vitality and self-efficacy in the subjects (50). With all of these conditions being affected by yoga, there have to be potential mechanisms that could explain this reduction in pain.

There are three known potential mechanisms for yoga reducing pain. First is the "Gate theory." As explained by Field, "pain stimulates shorter and less myelinated nerve fibers so that the pain signal takes longer to reach the brain than the pressure signal which is carried by nerve fibers that are more insulated and longer and therefore able to transmit the stimulus faster. The message from the pressure stimulation reaches the brain prior to the pain message and "closes the gate" to the pain stimulus" (5). Essentially, yoga is a form of self-massage where limbs rub against limbs and against the floor to stimulate pressure receptors to produce this response. Another potential mechanism for yoga to reduce pain is the deep sleep theory. In deep sleep, less substance P is emitted and therefore less pain occurs because substance P causes pain (5). Yoga enhances sleep measures (41, 42) and could possibly cause practitioners to spend more time in deep sleep. The third potential mechanism is increased serotonin. The body's natural anti-pain chemical, serotonin, increases with yoga (5). These mechanisms may function as a group, rather than independently, but they could all be a potential reason yoga can alter pain syndromes.

Cardiovascular conditions can also be affected by participation in yoga. Coronary artery disease being one of those conditions that have been studied, patients with advanced coronary artery disease have benefited from yoga (51). At the end of one year of yoga training cholesterol was reduced by 23% and serum low-density lipids also decreased more in the yoga group (26%)(51). In a study that combined yoga with diet change, they found the experimental group had fewer angina episodes per week, improved exercise capacity, decreased body weight, and lower serum total cholesterol levels (52). Subjects also exhibited low-density lipoprotein, cholesterol, and triglyceride level decreases (52). Yet, it is important to note that this study had the addition of diet change, which was also implemented in the control group, which could have played a role in these changes. Heart failure patients are another group of subjects that have benefited from yoga. Yoga practice led to improved cardiovascular endurance and decreased inflammatory markers (Interleukin-6 and C- reactive protein) to suggest positive immune effects of yoga in patients with heart failure (53). The cardiovascular condition of hypertension is extremely important to prevent in older adults and yoga can play a role in this prevention. Yoga practiced daily for one hour for three months decreased blood pressure, blood glucose, cholesterol and triglycerides and improve subjective well-being and quality of life in patients who have mild to moderate hypertension (54). Furthermore, after 20 weeks of yoga, patients at risk for cardiovascular disease had decreased systolic and diastolic blood pressure (55). With increased age, chronic illness often necessitates use of medications to treat such problems as hypertension. Antihypertensive medications may cause the unwanted side effect of orthostatic hypotension and place the senior at an increased risk of falls (6). Yoga offers a natural solution for seniors by decreasing the need for some medications and lessening the chance of unwanted side effects and potential medication interactions (56). The decreased need for medication has the potential to directly improve postural control in older adults.

Autoimmune conditions seem to respond to yoga as they do to massage, possibly via the stimulation of pressure receptors and the resulting parasympathetic state following increased vagal activity (5). As for asthma patients, two hour sessions once a week for 4 months resulted in improvements in Asthma-Related Quality of Life Questionnaire, the Profile of Mood States, and a diary card based on the combined Asthma Score reflecting asthma symptoms, bronchodilator usage and peak expiratory flow rates (57). Diabetes has also been shown to improve following a yoga intervention. Yoga for 30-40 min per day for 40 days resulted in decreases in blood glucose levels and glycosylated hemoglobin levels, heart rate, systolic and diastolic blood pressures (58). Yoga may have therapeutic effects on diabetes by decreasing oxidative stress and improving antioxidant status (59). Immune conditions have been studied with yoga intervention groups, but actual immune function was not studied in all of the yoga studies found on immune conditions. Instead, the studies measured psychological functions. It is expected that these changes would alter immune function via the decrease of stress hormones. Nonetheless, yoga has been studied in Lymphoma patients and in women with breast cancer for lower sleep disturbance scores (60), less anxiety (61), less pain, and less fatigue (62).

Physiological effects of a yoga intervention have also been studied. One study had a yoga group practice yoga postures for 45 minutes daily for three months while the control group performed flexibility exercises for 40 minutes and slow running for 20 minutes daily for 3 months (63). The yoga group showed greater decreases in heart rate and blood pressure and greater aerobic performance than the subjects in the control group (63). Another interesting finding pertains to the basil metabolic rate (BMR) of subjects. The BMR of yoga practitioners was significantly lower than that of the non-yoga group and of their predicted values (64). This is probably linked to reduced arousal with the long-term practice of yoga using a combination of stimulatory and inhibitory yogic practices. An unfortunate consequence of this decrease in BMR is that it could create a propensity for weight gain and fat deposition if the practice is discontinued (64). An additional physiological effect of yoga deals with response to hypoxia. The slow breathing techniques associated with yoga postures have been shown to substantially reduce chemoreflex sensitivity to hypoxia, especially after long-term practice (65). Increased sensitivity to hypoxia is thought to be responsible for the breathing dyspnea experienced by patients with congestive heart failure (65). There are also slow increases in lung capacity in yoga practitioners. Well-practiced yoga breathing recruits normally unventilated lung and helps to match ventilation to profusion better, thereby increasing oxygen delivery to highly metabolic tissues (65). These changes may allow an older adult to perform more appropriately to physical stresses.

Physical effects are also seen as a result of yoga practice. Firstly, weight loss is known to occur in response to yoga. 12 weeks of yoga led to an overall reduction in food consumption, in eating speed and in food choices in subjects (66). Yoga practice for four years was also associated with a 3-pound lower weight gain among normal weight participants and a 19-pound lower weight gain among overweight participants (67). A simple six-day yoga program even led to decreased body mass index, waist and hip circumference, fat-free mass, total cholesterol, high-density lipoprotein and fasting serum leptin levels (68). Likewise, eating disorder symptoms have also decreased following yoga in recent research (69). Weight loss is far from the only physical effect seen in response to initiation of a yoga program. A short-term yoga program of 24 yoga sessions in 8 weeks led to improved balance, and leg strength and leg muscle control increased (70). Another study of leg strength looked at senior women who participated in yoga who had increased strength, improved leg muscle endurance, and significant improvements in balance as a result of yoga (71).

The focus of the present study is on the affects of yoga on balance. It has been shown that those individuals whom have been doing yoga longer and those who devoted more time to yoga practice were characterized by more correct body stance in Mountain Pose (72). More correct body stance is beneficial for quiet standing, yet this study did not look at body stance in other positions or in gait, while the present study explores different stances. In a study on the elderly, 6 months of weekly Hatha yoga classes were followed by improved physical condition in terms of balance (measured by one-legged standing) and flexibility (10). Balance as a whole is not simply measured my one-legged standing. Instead, each of the six resources of postural control and postural orientation must be assessed. Therefore, the present study tests each resource area to give a well-rounded review of their balance. In an 8 week yoga program, seniors increased hip extension, increased stride length, and decreased anterior pelvic tilt (56), yet they did not perform an in-depth review of each individual's balance or look at the long-term effects of yoga. To truly understand the benefits of yoga in terms of balance, we must look at the long-term effects in individuals whom have been practicing between 8 weeks and multiple years. Multiple sclerosis patients also did an 8-week Hatha yoga intervention and showed significant improvement on balance score, walking endurance, fatigue severity scale, and some of the quality of life scale scores (73). In the case of musculoskeletal disorders, physical activity tends to become restricted in parallel with pain experienced by the individual. A study showed that in only eight sessions, patients gait and balance (gait pattern, less step length differences, higher gait speed and range, and equal overall distribution of force to maintain front-back and side balance) parameters were statistically higher and it is possible to use yoga programs to solve problems caused by musculoskeletal disorders (74), which would have major impacts on elderly balance problems. As mentioned in previous sections of this review of literature, postural control is much more than simply a sensory and motor collaboration to maintain appropriate balance control. If yoga is able to improve these measures, it is reasonable to predict that habitual yoga will improve the balance measures of older adults.

It is not entirely known why might yoga affect balance. There are a few postulations that will now be reviewed in more detail. One of the first possible mechanisms of yoga's affect on balance is the increased vagal activity and the resulting decreased cortisol levels (5). It is well established that massage therapy increases vagal activity and vagal activity decreases cortisol, which is associated with decreased depression. Yoga is a form of self-massage in which the practitioner rubs limbs together and against the floor to increase vagal activity via stimulation of pressure receptors (5). Moreover, this may improve physical and mental health through down-regulation of the hypothalamic pituitary-adrenal axis and the sympathetic nervous system (9). The hypothalamic pituitary-adrenal axis and the sympathetic nervous system are triggered as a response to a physical or psychological demand, leading to a cascade of physiologic, behavioral, and psychological effects, primarily as a result of the release of cortisol and catecholamines (9). The constant state of hypervigilence resulting from repeated firing of the hypothalamic pituitary-adrenal axis and the sympathetic nervous system can lead to improper regulation of the system and ultimately diseases such as obesity, diabetes, autoimmune disorders, depression, substance abuse, and cardiovascular disease (9) The increases in vagal activity could reduce the hypervigilence seen with stress and allow yoga to be as effective as or superior to exercise on nearly every outcome measured (9). Studies about the postulation need to be looked into further before any conclusions are made.

Another possible explanation for the reason yoga elicits benefits seen in postural control is that improvements in physical measures directly relate to the yoga intervention because yoga practice involves training on poses very similar to balance outcome measures (10). Yoga is theorized to be more therapeutic than traditional exercise because of the mind-body component and there is active engagement between the mind and the body. In yoga, "the mind is encouraged to focus specifically on what is occurring in the body and where the body is in space, increasing both awareness and proprioception" (75). This could allow the mind and body to be practiced in the tasks required in balance testing. Much like physical therapy, yoga teaches correct alignment in the asanas or postures that result in more correct posture in normal stances (72). This correct alignment in older adults could prevent falls, but no test has looked at a variety of stances and circumstances to test the postural orientation in the aging population. The practice of yoga also elicits better endurance through increases in muscle strength and flexibility that can decrease fatigue in a subject and improve ambulatory function through reduction of biomechanical constraints (73). Also, hand-eye coordination should see improvements after yoga intervention, like T'ai Chi because yoga practitioners have a set gaze for each posture. Aligning with this hand-eye coordination, the type of yoga may affect the improvement of this measure. The style of Bikram encourages practitioners to keep their eyes open and often gazing in a mirror at their own eyes while Hatha and Vinyasa styles often encourage the practitioner to close their eyes to challenge their balance and focus. The use of gaze has not been researched and no conclusions can be made. The present study will look at the types of yoga individuals are practicing and how the balance results, such as a stepping test, walking with head turns, and walking over obstacles, may change depending on the type of yoga practiced. Along these same lines of thought, yoga improves both physical and psychological well-being and decreases the need for certain medications. Less reliance on medication lowers the senior's chances of adverse affects from no longer required medications and reduces the chances of an unintentional fall.

The final postulation for why yoga elicits balance improvements has not been mentioned in previous literature to the researcher's knowledge. The possible reason is that repeated passive stretching, that occurs in yoga often, results in deterioration of muscle function and an immediate reduction in the reflex sensitivity (7). There is a reduction in the activity of the large-diameter afferents, resulting from the reduced sensitivity of the muscle spindles to repeated stretch (7). If these "symptoms" become chronic with habitual yoga practice, there is a chance that older adults are able to maintain their limits of stability with aging, rather than constraining the limits of stability. As a result, postural instability due to biomechanical constraints is greatly diminished. Research in reduced muscle spindle sensitivity would be something of interest if a significant difference were found in balance measures between habitual adult yoga practitioners and the control group.

Summary

The present review of literature covered balance, aging and balance, benefits of exercise on aging and balance, and the benefits of yoga. Each of these topics had to be reviewed prior to embarking on the study in this document. The following paragraphs are a summary of important aspects of each topic that were considered prior to developing this thesis.

The two main functional goals of postural behavior are postural orientation and postural equilibrium (3). In order to adequately assess the success of one's ability to achieve these goals, there are six resources that must be tested to determine any inadequacies. The resources that take into account the context in which the individual resides includes; sensory strategies (sensory integration and sensory rewriting), movement strategies (reactive, anticipatory, and voluntary), biomechanical constraints (degrees of freedom, strength, and limits of stability), cognitive processing (attention and learning), control of dynamics (gait and proactive), and orientation in space (perception, gravity, surfaces, vision, and verticality) (3). Postural control is context-dependent and requires functional integration of each resource to appropriately achieve static and dynamic stability. The present test takes each of the resources into account, unlike any other study on yoga practitioners.

It is well known that scores in each of these resources decline with age. The effect of age on postural control is quite small, but a small decrease in postural stability due to age alone is the increased probability in the elderly of developing specific pathologies, which lead to accelerated degeneration in neural and/or musculoskeletal systems (4). One example of a small decrease in postural control is the hypersensitivity to changes in postural orientation that can cause a shift in movement patterns. Older individuals tend to use the hip strategy as well as the stepping strategy to maintain postural stability (3). The hip and stepping strategies are intended for recovery from large perturbations, yet older adult (65-75 years old) hypersensitivity to postural changes cause a larger than necessary recovery method selection. Incorrect selection is just one example of what can occur with balance as a result of aging. The public health community is trying to determine preventative measures to decrease the hypersensitivity. Therefore, the present study looks at the years leading up to the dramatic decrement in postural control to determine if the decline can be prevented by yoga. Other examples of inaccuracy frequently seen in older adults include latency to postural response, motor learning, biomechanical constraints, inaccurate detection of head and body position and motion, adaptive weighting to sensory inputs, internal maps of postural stability limits, and integration of sensory information with motor performance. Every individual's deficiencies are highly complex and context dependent. Therefore, postural orientation measurements must test a plethora of circumstances to possibly detect balance deficits.

While postural control is definitely an important factor to research in the aging population, other pathologies could also play a role in postural control. Different forms of exercise have been shown to lower the risk of cardiovascular disease, increase cardiovascular functional capacity, aid in the control of diabetes, reduce the incidence of obesity, and decrease anxiety and depression. Postural control constitutes a limiting factor for many daily activities and a variety of physical exercises; training of the highly adaptable postural control can directly influence performance in those activities (14). As a result, exercise has been shown to affect balance by decreasing the number and probability of falling (22), induce adaptations in all of the sensory systems assisting in postural control (14), retraining the neural control of balance, decreasing the response frequency of antagonist muscles and increasing the response frequency of the trunk flexor muscles (23), and maintaining strength and muscle mass (21). Each of these factors can greatly improve the lives of older adults.

Yoga, like many other exercises, has been shown to improve the rate of decline in postural stability and other pathologies that tend to increase with age. A review done by Tiffany Field in 2010 on the effects of yoga in clinical research helps us have an overview of all the benefits of yoga that have been studied. Psychological symptoms and disorders, pain syndromes, cardiovascular conditions, autoimmune conditions, immune conditions, pregnancy conditions, physiological effects, and physical effects are all seen to improve with yoga practice (5). Physiologically, yoga is designed to stretch and tone the muscles of the body and to keep the spine and joints flexible (5), but it is obvious that yoga benefits are multifaceted and target a number of factors that make seniors vulnerable to experiencing falls (6) and developing pathology that may cause this vulnerability.

There are a number of postulations that could explain why yoga elicits balance improvements that were explained in the previous section, but I believe the most promising school of thought has yet to be researched. There is a possibility that repeated passive stretching, which occurs in yoga often, results in chronic reductions in reflex sensitivity. Essentially, there is a reduction in the activity of the large-diameter afferents, resulting from the reduced sensitivity of the muscle spindles to repeated stress (7), and this allows older adults to desensitize their muscle spindle degrees of freedom prior to a reflex. Individuals not participating in yoga will experience diminishing degrees of freedom while yoga practitioners will maintain their limits of stability, much like younger adults. This is an area of research that can extend from the present study if postural control differences are recorded between habitual yoga practitioners and the healthy control subjects. The other noteworthy postulation on why yoga improves balance scores is due to the similarities between practiced postures and testing protocols. Therefore, the present study needed to take a multi-faceted approach to include all postural control resources as well as indices for fear of falling and a number of recent unintentional falls to fully understand the yoga practitioner's balance.

Chapter 3

PROCEDURES FOR COLLECTING DATA

The Opening Paragraph

The problem of the study was to examine differences in static postural sway, biomechanical constraints, stability limits, postural responses, anticipatory postural adjustments, sensory orientation, and stability in gait in habitual adult yoga practitioners and healthy adults. The conduct of the study included the following organizational steps: (a) arrangements for conducting the study; (b) selection of measurement tools; (c) design of the study; (d) selection of subjects; (d) procedures for testing and gathering data; and (e) treatment of data.

Arrangements for Conducting the Study

The study was conducted in the Indiana University Exercise Science Laboratory in Bloomington, Indiana, DePauw University in Greencastle, Indiana, Indiana University – Purdue University Indianapolis in Indianapolis, IN, Quest for Balance Studio in Crawfordsville, IN, and The Villas at Ridgefield Farm Clubhouse in Danville, KY upon receipt of approval from the Institutional Review Board of Indiana University. The purposes, objectives, and details of the study were presented to local yoga studio owners and instructors in search of individuals that may qualify to take part in the study. Consultation with these individuals and the posting of flyers led to the exchange of email addresses for individuals that may qualify for the study. An email was sent to potential subjects that included the following: study information sheet, consent forms, balance health history questions (including the FES-I), date of birth, gender, yoga history questions, and scheduling information.

Selection of Measurement Tools

The Balance Evaluation Systems Test (76)was selected to assess the balance abilities of the subjects. One questionnaire was selected to assess the daily activity level of the subjects: The Global Physical Activity Questionnaire (77). One questionnaire was selected to assess the fear of falling of the subjects: Falls Self-Efficacy Scale – International (78).

The Balance Evaluation Systems Test (BESTest) consists of 36 items, grouped into the 6 following systems: “Biomechanical Constraints,” “Stability Limits/Verticality,” “Transitions/Anticipatory Postural Adjustments,” “Postural Responses,” “Sensory Orientation,” and “Stability in Gait.” The test yields raw scores from each item on a 4-level, ordinal scale from 0 (worst performance) to 3 (best performance), summed for each section, and then summed to produce a total summary of performance. Individual items are listed in Table 1. Specific rating instructions and stopwatch/ruler values are used to improve reliability. The framework for the development of the balance assessment tool was to separate control of balance into its underlying systems based on the scientific literature about laboratory measures of postural disorders in elderly people and in people with neurological disorders. The test has excellent interrater reliability for total score (ICC = 0.91) and for test subsections (range of ICC 0.79-0.92) when studying community dwelling adults with and without balance deficits as reported by the authors of the test (79). The BESTest test-retest (ICC > 0.88) reliability is also high as reported by the authors of the test (11). The depth of the test is essential to detect subtle differences between the experimental yoga group and the healthy control group.

Table 1.

Summary of Balance Evaluation Systems Test (BESTest) Items Under Each System Category (76)

I. Biomechanical Constraints	II. Stability Limits/Verticality	III. Anticipatory Postural Adjustments	IV. Postural Responses	V. Sensory Orientation	VI. Stability in Gait
1. Base of support	6. Sitting verticality (left and right) and lateral lean (left and right)	9. Sit to stand	14. In-place response, forward	19. Sensory integration for balance (stance on firm surface and stance on foam)	21. Gait, level surface
2. CoM alignment	7. Functional reach forward	10. Rise to toes	15. In-place response, backward	20. Incline, eyes closed	22. Change in gait speed
3. Ankle strength and ROM	8. Functional reach lateral (left and right)	11. Stand on one leg (left and right)	16. Compensatory stepping correction, forward		23. Walk with head turns, horizontal
4. Hip/trunk lateral strength		12. Alternate stair touching	17. Compensatory stepping correction, backward		24. Walk with pivot turns
5. Sit on floor and stand up		13. Standing arm raise	18. Compensatory stepping correction, lateral (left and right)		25. Step over obstacles
					26. Timed "Get Up & Go" Test
					27. Timed "Get Up & Go" Test with dual task

CoM=center of mass, ROM=range of motion

The Global Physical Activity Questionnaire (GPAQ) is a short, in-person survey that covers several components of physical activity in a subject's daily life (77). This includes physical activity variables such as intensity, duration, and frequency. The survey also assesses three domains in which physical activity is performed (occupational physical activity, transport-related physical activity, and physical activity during discretionary or leisure time). This is extremely important information to attain from each subject to assure significant differences in activity levels do not exist between the experimental and control group.

The Fall Self-Efficacy Scale – International is a questionnaire that assesses fear of falling through asking subjects to rate, on a four-point Likert scale, their concerns about the possibility of falling when performing 16 activities (80). These activities include cleaning the house (e.g. sweep, vacuum or dust), getting dressed or undressed, preparing simple meals, taking a bath or shower, going to the shop, getting in or out of a chair, going up or down stairs, walking around in the neighborhood, reaching for something above your head or on the ground, going to answer the telephone before it stops ringing, walking on a slippery surface (e.g. wet or icy), visiting a friend or relative, walking in a place with crowds, walking on an uneven surface (e.g. rocky ground, poorly maintained pavement), walking up or down a slope, going out to a social event (e.g. religious service, family gathering or club meeting) (78). The FES-I exhibits excellent internal consistency (Cronbach's alpha – 0.96) and test-retest reliability (ICC – 0.96) (80). The 16 items of the FES-I demonstrate mean inter-item correlations of 0.55 (80). In terms of validity, the predictive validity of the FES-I reveals that the questionnaire accurately predicts future falls, physiological falls risk, muscle weakness, overall disability, and depressive symptoms with a cut point of > 23 for high fear of falling scores (80).

Design of the Study

Subjects were selected based on their answers on the initial email contact and assigned to either the control group or the yoga group. Both groups completed the entire testing protocol on a single day that was convenient to the individual subject. Each subject was asked to refrain from ingesting any substance that may alter his or her balance during the 24 hours prior to testing. This includes, but is not limited to, alcohol, caffeine, and balance altering medications. Every subject was also asked to not take part in any physically exhaustive exercise during the 24 hours prior to testing. Each test measure was taken during a single testing session by the investigator in the Indiana University Exercise Science Laboratory, the DePauw University Exercise Science Laboratory, the Indiana University-Purdue University Indianapolis Exercise Science Laboratory, the Quest for Balance Studio, and the Villas at Ridgefield Farm Clubhouse.

Selection of Subjects

All of the subjects were volunteers. The main criteria for inclusion in the yoga group included; (a) all subjects minimum and maximum age of 55 and 70, respectively, (b) all subjects claimed to have a minimum of eight weeks of experience in practicing yoga at least three times per week, (c) all subjects claimed to have no history of diagnosed balance disorders, and (d) all subjects were not currently in pain. The main criteria for inclusion in the control group included; (a) all subjects minimum and maximum age of 55 and 70, respectively, (b) all subjects claimed to not be currently participating in a yoga exercise regimen, (c) all subjects claimed to have no history of diagnosed balance disorders, and (d) all subjects were not currently in pain.

These criteria were selected to give the study an external validity factor that would allow the results to be generalized to a population of adult yoga practitioners. This population was selected because the practice of yoga is growing in popularity, and it is well suited to the adult population for low-impact, low-intensity sport. The number of years of practicing yoga, and the emphasis on minimum and maximum age added power to the analysis of the experimental data by reducing the intersubject variance in scores and reassuring the practice of yoga was a habitual act.

Procedures for Testing and Gathering Data

Permission was obtained from the owners of a variety of yoga studios to contact individuals that they believe to possibly qualify for the study as well as post flyers in the studio spaces. The investigator sent an email to possible candidates about the study and asked them to fill out an online survey and informed consent if they were interested in participating. Questions addressed birth date, gender, neurological health history, fear of falling information (FES-I), yoga participation characteristics, and subject availability. The investigator then identified individuals that qualified for the experimental group as defined in the study and contacted that individual to establish a time for testing and gave instructions on pre-test protocol (no balance altering substances within 24 hours and arrive in comfortable exercise clothing.)

Upon arrival, subjects were measured for height using a stadiometer and weight using an Aria fitbit scale. Next, subjects were seated for the duration of the GPAQ. The instructor first read aloud the instructions for each section of the questionnaire and then asked the questions with supportive show cards for each of the activity types covered by the GPAQ. The investigator recorded each answer to 16 questions on paper.

Once the GPAQ was completed, the investigator began the BESTest protocol (76). Subjects were instructed to take shoes and socks off. This test provides instructor and patient instructions for each section of the test as well as a scoring guide. These instructions for each item are listed below and were followed in their entirety.

1. BASE OF SUPPORT
    a. Examiner Instructions: Closely examine both feet to look for deformities or complaints of pain such as abnormal pronation/supination, abnormal or missing toes, pain from plantar fascitis, bursitis, etc).
    b. Patient: Stand up in your bare feet and tell me if you currently have any pain in your feet or ankles or legs.
    c. Scoring: (3) Normal: Both feet have normal base of support with no deformities or pain (2) One foot has deformities and/or pain (1) Both feet has deformities OR pain (0) Both feet have deformities AND pain
2. CoM ALIGNMENT
    a. Examiner Instructions: Look at the patient from the side and imagine a vertical line through their center of body mass (CoM) to their feet. (The CoM is the imaginary point inside or outside the body about which the body would rotate if floating in outer-space.) In an adult, standing erect, a vertical line through the CoM to the support surface is aligned in front of the vertebrae at the umbilicus and passes about 2 cm in front of the lateral malleolus, centered between the two feet. Abnormal segmental postural

alignment such as scoliosis or kyphosis or asymmetries may or may not affect CoM alignment.

b. Patient: Stand relaxed, looking straight ahead

c. Scoring: (3) Normal AP and ML CoM alignment and normal segmental postural alignment (2) Abnormal AP OR ML CoM alignment OR abnormal segmental postural alignment (1) Abnormal AP OR ML CoM alignment AND abnormal segmental postural alignment (0) Abnormal AP AND ML CoM alignment

3. ANKLE STRENGTH & RANGE

a. Examiner Instructions: Ask the patient rest their fingertips in your hands for support while they stand on their toes has high as possible and then stand on their heels. Watch for height of heel and toe lift.

b. Patient: Rest your fingers in my hands for support while you stand on your toes. Now stand on your heels by lifting up your toes. Maintain each position for 3 sec.

c. Scoring: (3) Normal: Able to stand on toes with maximal height and to stand on heels with front of feet up (2) Impairment in either foot of either ankle flexors or extensors (i.e. less than maximum height) (1) Impairment in two ankle groups (eg; bilateral flexors or both ankle flexors and extensors in 1 foot) (0) Both flexors and extensors in both left and right ankles impaired (i.e. less than maximum height)

4. HIP/TRUNK LATERAL STRENGTH

a. Examiner Instructions: Ask the patient to rest their fingertips in your hands while they lift their leg to the side off the floor and hold. Count for 10 sec while their foot is off the floor with a straight knee. If they must use moderate force on your hands to keep their trunk upright, score as without keeping trunk vertical.

b. Patient: Lightly rest your fingertips in my hands while you lift your leg out to the side and hold until I tell you to stop. Try to keep your trunk vertical while you hold your leg out.

c. Scoring: (3) Normal: Abducts both hips to lift the foot off the floor for 10 s while keeping trunk vertical (2) Mild: Abducts both hips to lift the foot off the floor for 10 s but without keeping trunk vertical (1) Moderate: Abducts only one hip off the floor for 10 s with vertical trunk (0) Severe: Cannot abduct either hip to lift a foot off the floor for 10 s with trunk vertical or without vertical

5. SIT ON FLOOR AND STANDUP

a. Examiner Instructions: Start with the patient standing near a sturdy chair. The patient can be considered to be sitting when both buttocks are on the floor. If the task takes more than 2 minutes to complete the task, with or without a chair, score 0. If the patient requires any physical assistance, score 0.

b. Patient: Are you able to sit on the floor and then stand up, in less than 2 minutes? If you need to use a chair to help you go onto the floor or to stand up, go ahead but your score will be affected. Let me know if you cannot sit on the floor or stand up without my help.

c. Scoring: (3) Normal: Independently sits on the floor and stands up

   (2) Mild: Uses a chair to sit on floor OR to stand up

   (1) Moderate: Uses a chair to sit on floor AND to stand up

   (0) Severe: Cannot sit on floor or stand up, even with a chair, or refuses

6. VERTICALITY AND LATERAL LEAN

   a. Examiner Instructions: Patient is sitting comfortably on a firm, level, armless surface (bench or chair) with feet flat on floor. It is okay to lift ischium or feet when leaning. Watch to see if the patient returns to vertical smoothly without over or undershooting. Score the worst performance to each side.

   b. Patient: Cross your arms over your chest. Place feet shoulder width apart. I'll be asking you to close your eyes and lean to one side as far as you can. You'll keep your spine straight, and lean sideways as far as you can without losing your balance OR using your hands. Keeping your eyes closed, return to your starting position when you've leaned as far as you can. It's okay to lift your buttocks and feet. Close your eyes Lean now. (REPEAT other side)

   c. Scoring:

      i. Lean (both sides): (3) Maximum lean, subject moves upper shoulders beyond body midline, very stable (2) Moderate lean, subject's upper shoulder approaches body midline or some instability (1) Very little lean, or significant instability (0) No lean or falls (exceeds limits)

ii. Verticality (both sides): (3) Realigns to vertical with very SMALL or no OVERSHOOT (2) Significantly over- or under-shoots but eventually realigns to vertical (1) Failure to realign to vertical (0) Falls with the eyes closed

7. FUNCTIONAL REACH FORWARD

   a. Examiner Instructions: Examiner places the ruler at the end of the fingertips when the arms are out at 90 degrees. The patient may not lift heels, rotate trunk, or protract scapula excessively. Patient must keep their arms parallel to ruler and may use less involved arm. The recorded measure is the maximum horizontal distance reached by the patient. Record best reach.

   b. Patient: Stand normally. Please lift both arms straight in front of you, with fingertips held even. Stretch your fingers and reach forward as far as you can. Don't lift your heels. Don't touch the ruler or the wall. Once you've reached as far forward as you can, please return to a normal standing position. I will ask you to do this two times. Reach as far as you can.

   c. Scoring: (3) Maximum to limits: >32 cm (12.5 in) (2) Moderate: 16.5 cm - 32 cm (6.5 – 12.5 in) (1) Poor: < 16.5 cm (6.5 in) (0) No measurable lean – or must be caught

8. FUNCTIONAL REACH LATERAL

   a. Examiner Instructions: Have subject align feet evenly so that the fingertips, when the arm is out at 90 degrees is at the start of the ruler. The recorded measure is the maximum horizontal distance reached by the patient. Record the best reach. Make sure the subject starts in neutral. The patient is allowed to lift one heel off the floor but not the entire foot.

b. Patient: Stand normally with feet shoulder width apart. Arms at your sides. Lift your arm out to the side. Your fingers should not touch the ruler. Stretch your fingers and reach out as far as you can. Do not lift your toes off the floor. Reach as far as you can. (REPEAT other side)

c. Scoring (both sides): (3) Maximum to limit: > 25.5 cm (10 in) (2) Moderate: 10-25.5 cm (4-10 in) (1) Poor: < 10 cm (4 in) (0) No measurable lean, or must be caught

9. SIT TO STAND

    a. Examiner Instructions: Note the initiation of the movement, and the use of hands on the arms of the chair or their thighs or thrusts arms forward

    b. Patient: Cross arms across your chest. Try not to use your hands unless you must. Don't let your legs lean against the back of the chair when you stand. Please stand up now.

    c. Scoring: (3) Normal: Comes to stand without the use of hands and stabilizes independently (2) Comes to stand on the first attempt with the use of hands (1) Comes to stand after several attempts or requires minimal assist to stand or stabilize or requires touch of back of leg or chair (0) Requires moderate or maximal assist to stand

10. RISE TO TOES

    a. Examiner Instructions: Allow the patient to try it twice. Record the best score. (If you suspect that subject is using less than their full height, ask them to rise up while holding the examiners' hands.) Make sure subjects look at a target 4-12 feet away.

b. Patient: Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I'll count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now.

c. Scoring: (3) Normal: Stable for 3 sec with good height (2) Heels up, but not full range (smaller than when holding hands so no balance requirement) -OR- slight instability & holds for 3 sec (1) Holds for less than 3 sec (0) Unable

11. STAND ON ONE LEG

a. Examiner Instructions: Allow the patient two attempts and record the best. Record the sec they can hold posture, up to a maximum of 30 sec. Stop timing when subject moves their hand off hips or puts a foot down.

b. Patient: Look straight ahead. Keep your hands on your hips. Bend one leg behind you. Don't touch your raised leg on your other leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now. (REPEAT other side)

c. Scoring (both sides): (3) Normal: Stable for > 20 s (2) Trunk motion, OR 10-20 s (1) Stands 2-10 s (0) Unable

12. ALTERNATE STAIR TOUCHING

a. Examiner Instructions: Use standard stair height of 6 inches. Count the number of successful touches and the total time to complete the 8 touches. It's permissible for subjects to look at their feet.

b. Patient: Place your hands on your hips. Touch the ball of each foot alternately on the top of the stair. Continue until each foot touches the stair four times (8 total taps). I'll be timing how quickly you can do this. Begin now.

c. Scoring: (3) Normal: Stands independently and safely and completes 8 steps in < 10 seconds (2) Completes 8 steps (10-20 seconds) AND/OR show instability such as inconsistent foot placement, excessive trunk motion, hesitation or arhythmical (1) Completes < 8 steps – without minimal assistance (i.e. assistive device) OR > 20 sec for 8 steps (0) Completes < 8 steps, even with assistive devise

13. STANDING ARM RAISE

a. Examiner Instructions: Use 2.5 Kg (5 lb) weight. Have subjects stand and lift weight with both hands to shoulder height. Subjects should perform this as fast as they can. Lower score by 1 category if weight must be less than 2.5 Kg (5 lb) +/or lifts < 75 deg.

b. Patient: Lift this weight with both hands from a position in front of you to shoulder level. Please do this as fast as you can. Keep your elbows straight when you lift and hold. Hold for my count of 3. Begin now.

c. Scoring: (3) Normal: Remains stable (2) Visible sway (1) Steps to regain equilibrium/unable to move quickly w/o losing balance (0) Unable, or needs assistance for stability

14. IN PLACE RESPONSE- FORWARD

a. Examiner Instructions: Stand in front of the patient, place one hand on each shoulder and lightly push the patient backward until their anterior ankle muscles contract, (and toes just start to extend) then suddenly release. Do not allow any pre-leaning by patient. Score only the best of 2 responses if the patient is unprepared or you pushed too hard.

b. Patient: For the next few tests, I'm going to push against you to test your balance reaction. Stand in your normal posture with your feet shoulder width apart, arms at your sides. Do not allow my hands to push you backward. When I let go, keep your balance without taking a step.

c. Scoring: (3) Recovers stability with ankles, no added arms or hips motion (2) Recovers stability with arm or hip motion (1) Takes a step to recover stability (0) Would fall if not caught OR requires assist OR will not attempt

15. IN PLACE RESPONSE- BACKWARD

a. Examiner Instructions: Stand behind patient, place one hand on each scapula and isometrically hold against patient's backward push, until heels are about to be lifted, not allowing trunk motion. Suddenly release. Do not allow any pre-leaning by patient. Score the best of 2 responses if patient is unprepared, or you pushed too hard.

b. Patient: Stand with your feet shoulder width apart, arms at your sides. Do not allow my hands to push you forward. When I let go, keep your balance without taking a step.

c. Scoring: (3) Recovers stability at ankles, no added arm / hip motion (2) Recovers stability with some arm or hip motion (1) Takes a step to recover stability (0) Would fall if not caught -OR- requires assistance -OR- will not attempt

16. COMPENSATORY STEPPING CORRECTION-FORWARD

   a. Examiner Instructions: Stand in front to the side of patient with one hand on each shoulder and ask them to push forward. (Make sure there is room for them to step forward). Require them to lean until their shoulders and hips are in front of their toes. Suddenly release your support when the subject is in place. The test must elicit a step. Be prepared to catch patient.
   b. Patient: Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall.
   c. Scoring: (3) Recovers independently a single, large step (second realignment step is allowed) (2) More than one step used to recover equilibrium, but recovers stability independently OR 1 step with imbalance (1) Takes multiple steps to recover equilibrium, or needs minimum assistance to prevent a fall (0) No step, OR would fall if not caught, OR falls spontaneously

17. COMPENSATORY STEPPING CORRECTION - BACKWARD

   a. Examiner Instructions: Stand in back and to the side of the patient with one hand on each scapula and ask them to lean backward. (Make sure there is room for them to step backward.) Require them to lean until their shoulders and hips are in back of their heels. Release your support when the subject is in place. Test must elicit step.
   b. Patient: Stand with your feet shoulder width apart, arms down at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall.

c. Scoring: (3) Recovers independently a single, large step (2) More than one step used, but stable and recovers independently OR 1 step with imbalance (1) Takes several steps to recover equilibrium, or needs minimum assistance (0) No step, OR would fall if not caught, OR falls spontaneously

18. COMPENSATORY STEPPING CORRECTION- LATERAL

a. Examiner Instructions: Stand behind the patient, place one hand on either the right (or left) side of the pelvis, and ask them to lean their whole vertial body into your hand. Require them to lean until the midline of pelvis is over the right (or left) foot and then suddenly release your support.

b. Patient: Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, step if you need to, to avoid a fall.

c. Scoring (Both sides): (3) Recovers independently with 1 step of normal length/width (crossover or lateral OK) (2) Several steps used, but recovers independently (1) Steps, but needs to be assisted to prevent a fall (0) Falls, or cannot step

19. SENSORY INTEGRATION FOR BALANCE (MODIFIED CTSIB)

a. Examiner Instructions: Do the tests in order. Record the time the patient was able to stand in each condition to a maximum of 30 seconds. Repeat condition if not able to stand for 30 s and record both trials (average for category). Use medium density Temper® foam, 4 inches thick. Assist subject in stepping onto foam. Have the subject step off the foam between trials. Include leaning or hip strategy during a trial as “instability.”

b. Patient: For the next 4 assessments, you'll either be standing on this foam or on the normal ground, with your eyes open or closed. Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Each time, stay as stable as possible until I say stop.

c. Scoring: Two trials for each assessment (eyes open-firm surface, eyes closed-firm surface, eyes open-firm surface, eyes closed-foam surface.) (3) 30s stable (2) 30s unstable (1) < 30s (0) Unable.

20. INCLINE EYES CLOSED

a. Examiner Instructions: Aid the patient onto the ramp. Once the patient closes their eyes, begin timing. Repeat condition if not able to stand for 30 s and average both trials/ Note if sway is greater than when standing on level surface with eyes closed (Item 15B) or if poor alignment to vertical. Assist includes use of a cane or light touch any time during the trial.

b. Patient: Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart. Place your hands on your hips. I will start timing when you close your eyes.

c. Scoring: Toes Up (3) Stands independently, steady without excessive sway, holds 30 sec, and aligns with gravity (2) Stands independently 30 SEC with greater sway than in item 19B -OR- aligns with surface (1) Requires touch assist -OR- stands without assist for 10-20 sec (0) Unable to stand >10 sec -OR- will not attempt independent stance

21. GAIT – LEVEL SURFACE

a. Examiner Instructions: Place two markers 20 feet (6 meters) apart and visible to the patient on a level walkway. Use a stopwatch to time gait duration. Have subjects start with their toes on the mark. Start timing with the stopwatch when the first foot leaves the ground and stop timing when both feet stop beyond the next mark.

b. Patient: Walk at your normal speed from here past the next mark and stop.

c. Scoring: (3) Normal: walks 20 ft., good speed (≤ 5.5 sec), no evidence of imbalance. (2) Mild: 20 ft., slower speed (>5.5 sec), no evidence of imbalance. (1) Moderate: walks 20 ft., evidence of imbalance (wide-base, lateral trunk motion, inconsistent step path) – at any preferred speed. (0) Severe: cannot walk 20 ft. without assistance, or severe gait deviations OR severe imbalance

22. CHANGE IN SPEED

a. Examiner Instructions: Allow the patient to take 2-3 steps at their normal speed, and then say “fast”, after 2-3 fast steps, say “slow”. Allow 2-3 slow steps before they stop walking.

b. Patient: Begin walking at your normal speed, when I tell you “fast” walk as fast as you can. When I say “slow”, walk very slowly.

c. Scoring: (3) Normal: Significantly changes walking speed without imbalance (2) Mild: Unable to change walking speed without imbalance (1) Moderate: Changes walking speed but with signs of imbalance, (0) Severe: Unable to achieve significant change in speed AND signs of imbalance

23. WALK WITH HEAD TURNS – HORIZONTAL

a. Examiner Instructions: Ask the patient to turn their head and hold it so they are looking over their shoulder until you tell them to look over the opposite shoulder every 2-3 steps. If the patient has cervical restrictions allow combined head and trunk movements (enbloc).

b. Patient: Begin walking at your normal speed, when I say “right”, turn your head and look to the right. When I say “left” turn your head and look to the left. Try to keep yourself walking in a straight line.

c. Scoring: (3) Normal: performs head turns with no change in gait speed and good balance (2) Mild: performs head turns smoothly with reduction in gait speed, (1) Moderate: performs head turns with imbalance (0) Severe: performs head turns with reduced speed AND imbalance AND/OR will not move head within available range while walking.

24. WALK WITH PIVOT TURNS

a. Examiner Instructions: Demonstrate a pivot turn. Once the patient is walking at normal speed, say “turn and stop.” Count the steps from turn until the subject is stable. Instability in the subject is indicated by wide stance width, extra stepping or trunk and arm motion.

b. Patient: Begin walking at your normal speed. When I tell you to “turn and stop”, turn as quickly as you can to face the opposite direction and stop. After the turn, your feet should be close together.

c. Scoring: (3) Normal: Turns with feet close, FAST (< 3 steps) with good balance. (2) Mild: Turns with feet close SLOW (>4 steps) with good balance (1) Moderate: Turns with feet close at any speed with mild signs of imbalance (0) Severe: Cannot turn with feet close at any speed and significant imbalance.

25. STEP OVER OBSTACLE

a. Examiner Instructions: Place the 2 stacked boxes (9" or 22.9 cm height) 10 ft. away from where the patient will begin walking. Use a stopwatch to time gait duration to calculate average velocity by dividing the number of seconds into 20 feet. Look for hesitation, short steps and touch on obstacle.
b. Patient: Begin walking at your normal speed. When you come to the shoe boxes, step over them, not around them and keep walking.
c. Scoring: (3) Normal: able to step over 2 stacked shoe boxes without changing speed and with good balance (2) Mild: steps over 2 stacked shoe boxes but slows down, with good balance (1) Moderate: steps over shoe boxes with imbalance or touches box. (0) Severe: cannot step over shoe boxes AND slows down with imbalance or cannot perform with assistance.

26. TIMED "GET UP & GO"

a. Examiner Instructions: Have the patient sit with their backs against the chair. Time the patient from the time you say, "go" until they return to sitting in chair. Stop timing when the patient's buttocks hit the chair bottom. The chair should be firm with arms to push from if necessary. TOOLS: TAPE ON FLOOR 3 METERS FROM THE FRONT OF THE CHAIR LEGS.
b. Patient: When I say "GO," stand up from the chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. I will time how long it takes.

c. Scoring: (3) Normal: Fast (11 sec with good balance) (1) Moderate: Fast (11 sec) AND imbalance.

27. TIMED "GET UP & GO" WITH DUAL TASK

a. Examiner Instructions: Before beginning, practice with the patient how to count backward from a number between 90 and 100 by 3s, to make sure they can do the cognitive task. Then ask them to count backwards from a different number and after a few numbers say GO for the GET UP AND GO TASK. Time the patient from when you say "go" until they return to sitting. Stop timing when the patient's buttocks touch the chair bottom. The chair should be firm with arms to push from if necessary.

b. Patient: a) Count backwards by 3's starting at 100 OR b) List random numbers and when I say "GO," stand up from the chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair but continue listing numbers.

c. Scoring: (3) Normal: No noticeable change between sitting and standing in the rate or accuracy of backwards counting and no change in gait speed. (2) Mild: Noticeable slowing, hesitation or errors in counting backwards OR slow walking (10%) in dual task (1) Moderate: Affects on BOTH the cognitive task AND slow walking (>10%) in dual task. (0) Severe: Can't count backward while walking or stops walking while talking

Once the final item of the BESTest was completed, subjects were finished with the entire test. They were informed to be expecting an email that included a review of their results.

Treatment of Data

The GPAQ data was cleaned and analyzed using the GPAQ analyzing guide (WHO, 2005) to produce an estimated metabolic equivalent (MET) for the ratio of a person's working metabolic rate relative to the resting metabolic rate. It is estimated that, compared to sitting quietly, a person's caloric consumption is four times as high when being moderately active, and eight times as high when being vigorously active. These scores were compared between groups using a 2-tailed t-test with a p-level of 0.05 to ensure the groups did not have differing daily activity levels that could have affected balance scores and the majority of the difference is due to the experimental group's involvement in yoga.

The BESTest was analyzed individually by section as well as by the BESTest total score. All of these values were compared between groups using a 2-tailed t-test with a p-level of 0.05.

Chapter 4

ANALYSIS AND DISCUSSION OF DATA

The problem of the study was to determine whether or not the habitual practice of yoga alters balance measures and associated fall risks when compared to individuals who do not practice yoga. Included in the study was an attempt to identify what areas of balance may be altered by the practice of yoga. The analysis of the data is presented in this chapter according to the following topics: (a) Demographic Data; (b) Balance Evaluation Systems Test Independent Group t-test Data; (c) Global Physical Activity Questionnaire Independent Group t-test data; (d) Falling Independent Group t-test Data; (e) Yoga Practitioner Univariate Analysis of Variance Data; and (f) Discussion of Findings.

Demographic Data

The population of subjects had no statistically significant differences between the yoga practitioner group and the healthy control group when applying the independent group t-test to age, sex, height, and weight. The results of the independent group t-test application are presented in Table 2.

Table. 2 Independent Group t-test for Demographic Data

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Significance (2-tailed)
Sex	Yoga	21	1.62	0.50	0.11	0.802
(1 = male, 2 = female)	Control	19	1.58	0.51	0.12	-
Age	Yoga	21	61.12	4.15	0.91	0.197
	Control	19	59.60	2.99	0.69	-
Height	Yoga	21	67.46	3.51	0.77	0.065
	Control	19	65.35	3.50	0.80	-
Weight	Yoga	21	161.55	30.92	6.75	0.264
	Control	19	173.55	36.01	8.26	-

A value of 0.05 was required for statistical significance at the P level of 0.05. Since the data did not meet the required alpha level, the null hypothesis that there is no significant difference between yoga practitioners and healthy controls in demographic data was accepted.

Balance Evaluation Systems Test Independent Group t-test Data

The independent group t-test analyses of the difference between means and the level of significance of the difference of means of the total BESTest scores and the individual sections of the BESTest are presented in Table 3.

Table 3. Independent Group t-test for BESTest Scores

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)	t	Mean Difference
BESTest Total Percent	Yoga	21	94.66	3.54	0.77	0.001*	4.36	5.24
	Control	19	89.43	4.06	0.93			
Biomechanical Constraints (I)	Yoga	21	14.00	0.89	0.20	0.001*	3.56	1.00
	Control	19	13.00	0.88	0.20			
Stability Limits (II)	Yoga	21	20.33	1.06	0.23	0.579	.56	0.18
	Control	19	20.16	0.90	0.21			
Transitions (III)	Yoga	21	17.24	1.22	0.27	0.005*	2.958	1.13
	Control	19	16.11	1.20	0.27			
Reactive Postural Response (IV)	Yoga	21	16.14	1.82	0.40	0.06	1.941	1.04
	Control	19	15.11	1.52	0.35			
Sensory Orientation (V)	Yoga	21	14.81	0.40	0.09	0.001*	3.56	0.91
	Control	19	13.89	1.10	0.25			
Stability in Gait (VI)	Yoga	21	19.71	0.90	0.20	0.001*	3.76	1.40
	Control	19	18.32	1.42	0.32			

*$P \leq 0.05$

A value of 0.05 was required for statistical significance at the P level of 0.05. Since the data met the required alpha level, the null hypothesis that there is no significant difference in balance performance as determined by the BESTest between habitual adult yoga practitioners and healthy adults was not accepted.

Global Physical Activity Questionnaire Independent Group t-test data

The independent group t-test analyses of the difference between means and the level of significance of the difference of means of the Global Physical Activity Questionnaire (GPAQ) are presented in Table 4. The GPAQ estimates a metabolic equivalence produced by an individual on a regular basis above their basal metabolic rate.

Table 4. Independent Group t-test for GPAQ.

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)	t	Mean Difference
Estimated METs	Yoga	21	6091.43	4857.91	1060.08	0.123	1.58	2278.80
	Control	19	3812.63	4219.51	968.02			

A value of 0.05 was required for statistical significance at the P level of 0.05. Since the data did not meet the required alpha level, the null hypothesis that there is no significant difference in daily activity patterns as determined by GPAQ between subjects was accepted.

Falling Independent Group t-test Data

The independent group t-test analyses of the difference between means and the level of significance of the difference of means of the Falls Self-Efficacy Scale International (FES-I) and the number of falls claimed in the past twelve months are presented in Table 5.

Table 5. Independent Group t-test for Falling Values

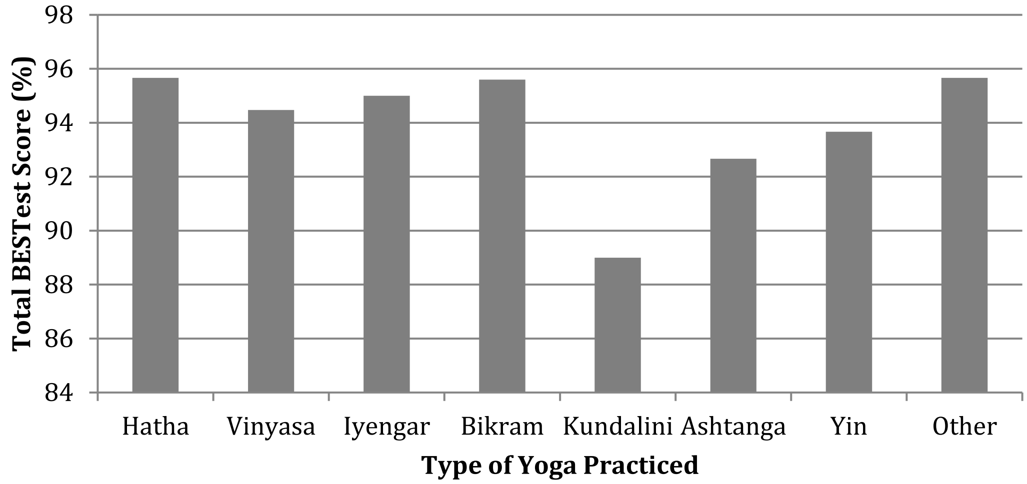
Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)	t	Mean Difference
FES-I Total Score	Yoga	21	17.76	2.76	0.60	0.537	.624	0.446
	Control	19	17.32	1.53	0.35			
Falls In Past 12 Months	Yoga	21	0.62	1.72	0.37	0.649	-.459	-0.328
	Control	19	0.95	2.74	0.63			

A value of 0.05 was required for statistical significance at the P level of 0.05. Since the data did not meet the required alpha level, the null hypothesis that there is no significant difference in fear of falling as determined by FES-I and in the number of claimed falls in the past twelve months between subjects was accepted.

Yoga Practitioner Univariate Analysis of Variance Data

The yoga practitioner data was analyzed by applying the univariate analysis of variance to grouped data. The yoga practitioners were divided by age into 55-60 years old, 60.01-65 years old, and greater than 65 years old. The amount of years the practitioner claimed to have been practicing was divided into 0-1 years, 1.1-5 years, and greater than 5 years. The amount of different types of yoga practiced was divided into 1 type, 2 types, and greater than 2 types. There was no statistically significant relationship between the three fixed factors (age, years of yoga, and types of yoga practiced) and the dependent variables of the total BESTest score and the FES-I score. According to a Tukey's Post-Hoc test, none of the groups within the fixed factors were significantly different between groupings. Since the data did not meet the required alpha level, the null hypothesis that there is no significant difference between a subject's age, duration of yoga practiced, and the number of different types of yoga practiced and balance performance as determined by the BESTest and fear of falling as determined by the FES-I was accepted. Chart 1 is a simple depiction of the average score of individuals that practice a specific type of yoga. Due to the limited subject pool, these averages are not reliable and cannot be applied to support any hypothesis.

Chart 1. Types of Yoga vs. Average BESTest Score



<u>Discussion of Findings</u>

The study found both significant and insignificant differences between the yoga group and the control group, but there are a few variables that stand out in the present study that will be delved into in this section. The discussion of the findings are presented in this section according to the following topics: (a) Demographic Data; (b) Balance Evaluation Systems Test; (c) Global Physical Activity Questionnaire; (d) Falling Data; (e) Yoga Practitioner Univariate Analysis of Variance; and (f) Summary and Conclusion.

Demographic Data. According to the independent groups t-test analysis done on the demographic data between groups, shown in Table 2, there are no differences in sex, age, height, or weight between groups. As a result, the groups can be considered demographically homogeneous and differences exposed between groups could truly be attributed to yoga participation, rather than the sex, age, height, or weight of the individuals.

Balance Evaluation Systems Test. The yoga group scored significantly higher than the control group for the BESTest total score to support the finding that yoga improves balance measures. The difference was expected due to a number of studies that have shown improvement in balance with yoga interventions (5, 70, 72, 81, 82). A study completed by Schmid, Puymbroeck, and Koceja in 2010 showed that after a 12-week yoga intervention in retirement community dwelling individuals there was a 4% increase in static balance measures and flexibility increased by 34% (75). The present study, as shown in Table 3, found habitual yoga practice to improve a subject's total balance score by 5.2%. The overall score included a plethora of balance measures, rather than focusing on static balance measures and flexibility. Further studies have shown that a yoga intervention has the potential to improve balance in a variety of age ranges (6, 70, 83, 84). Yet, the gross majority of these studies generalized measures of balance rather than looking at a set of functional components that summate into a complex skill based interaction known as balance. The present study is the first of it's kind to specifically look cross-sectionally at the functional components of balance in aging adult yoga practitioners. More specifically, there were statistical differences between certain sections on the BESTest that we will look into further to support the significant relationship between yoga and balance.

The first section was the measurement of biomechanical constraints in the BESTest looked at the quality of the base of support; the feet. In this particular group of individuals, the yoga practitioners scored significantly higher than individuals who did not practice yoga and this suggests that yoga could improve the strength, range, pain, or control of the feet. The significant difference in biomechanical constraints between groups aligns with a study mentioned previously, which suggested that due to a 34% increased lower-body flexibility, a 12-week yoga intervention could improve balance (75). While the study found extremely significant improvements in lower-body flexibility, the present study looked specifically at the biomechanical constraints of the feet and hips to find that the yoga practitioners scored 6.7% higher than the control group. The lack of biomechanical constraints in the yoga population could greatly improve the maintenance of balance while aging.

The second section was the measurement of stability limits and there was no significant difference seen between groups, according to Table 3. Limits of stability, that is, "how far the body's center of mass can be moved over its base of support," can be affected by sensory deficits or by a stroke (11). The stability limits section was scored out of 21 points and both groups scored close to perfect scores (20.33 and 20.16 for the yoga and control groups, respectively) with only a 0.8% difference between groups. The lack in significance could suggest that this age group behaves as if they are young and none of the subjects have any diagnosed balanced disorders, so they may not be experiencing any stability limits yet. Therefore, the eligibility parameters were maintained and individuals with balance disorders were not included in the study.

The third section of the BESTest was transitions or anticipatory postural adjustments. There was a 6.3% difference between the scores of the two groups that was significant, as shown in Table 3. Anticipatory postural adjustment falls under the balance resource of movement strategies and they "serve to maintain postural stability by compensating for destabilizing forces associated with moving a limb" (3). The anticipatory postural adjustments prior to voluntary movements depend on "interaction of supplementary motor areas with the basal ganglia and brain-stem areas and result in instability during step initiation or during rapid arm movements while standing" (11). The present study suggests that yoga improves the maintenance of postural stability through anticipatory postural adjustments.

The fourth section, reactive postural response, was nearly significant (P = 0.06) between groups as shown in Table 3. Reactive postural response and stability limits both take into account movement strategies (including the ankle, hip, and step strategies). Therefore, it is expected that ostensibly healthy adults can successfully complete the tasks of this section to maintain balance without a fall. The ability to regain balance within a posture is practiced often in all types of yoga practices, so it is expected that yoga practitioners would sustain higher reactive postural responses than the control group subjects. As expected, with a 5.7% improvement in scores for yoga practitioners, the fourth section suggests a possible enhancement in the ability of a yoga practitioner to quickly regain balance when forced out of balance.

Sensory orientation was the fifth section of the BESTest and the two groups were found to be statistically different, yet again. The sensory orientation section combines the balance resources of sensory strategies and orientation in space to elucidate an individual's ability to adequately achieve postural equilibrium (3). The significant difference between groups was expected, due to the relation of the present study and a study done by Hart and Tracy in 2008, which looked at yoga as a steadiness training in young adults (70). They found that after 24 Bikram yoga sessions in eight weeks, the yoga group improved leg muscle control. The 6.1% difference between groups in the present study suggests that a yoga practitioner could be more functionally capable of appropriately integrating and reweighting sensory information while they maintaining a proper perception of verticality in space.

The final section of the BESTest was titled stability in gait. Once again, the yoga practitioner group scored statistically higher than the control group in this section. Gait is not something that is often practiced in yoga, so it is interesting that yoga practitioners scored so much better in this section. The affect of yoga on gait was expected due to findings of a previous study done by Gothe in 2013 (81). They found that yoga and a stretching routine equally improved the timed get-up-and-go test and an assessment of gait speed, which were both tests included in the present study. Gait and proactivity is under the balance resource of controlling dynamics (3). Changing from one posture to another requires the body to move the center of mass outside the base of foot support and the dynamic movement of gait requires complex control of that movement. Most forms of yoga require the practitioner to deliberately move from pose to pose, sometimes quickly, with the upmost of control and this may have been the reason for the 6.7% improvement in the yoga group's ability to maintain proper control of dynamics during gait in the BESTest.

When the demographic data of age, sex, height, and weight are kept equivalent between yoga practitioners and healthy controls, the differences between balance performances are extremely significant. Therefore, the present data suggests that individuals between the ages of 55 and 70 whom practice yoga regularly will score significantly higher than their non-yoga practicing peers. Improved balance scores indicate fewer propensities to unintentionally fall during normal daily activities at any age. Consequently, it is important to continue practicing yoga to maintain the superior balance score as the susceptibility to unintentionally fall increases with age.

Global Physical Activity Questionnaire. As shown previously in Table 4, the independent groups t-test between the yoga group and the control group for estimated metabolic equivalences as determined by the GPAQ suggested that there was no significant difference in daily activity levels between groups. The lack of a significant difference means that the control group completed the same amount of activity as the yoga group on a daily basis in terms of intensity and duration of activity. The lack of difference directly contradicts the concept that increasing activity increases balance and counteracts age related disorders (21). The present study suggests that not all exercise types are equally beneficial in improving balance. Yoga is known for its low-intensity, so it was considered a moderate recreational activity on the GPAQ and shared the same classification as a leisure walk or slow-paced swimming. Therefore, the only difference in activity is the addition or subtraction of yoga from the subject's weekly routine to develop the large differences in balance scores. Suggesting that yoga is an extremely beneficial, low-risk exercise that can be added to any individual's exercise regimen to improve balance.

Falling Data. As expected, the fear of falling and number of unintentional falls in the past twelve months independent groups t-test analysis deems the groups insignificantly different between each other, according to Table 5. The lack of difference could stem from the age group analyzed in the present study. The majority of unintentional falls begin once people have aged to 65 years and older, and the frequency of falls increases with age and frailty level (85). Both groups averaged below one fall in the past year, and both groups scored very low on the FES-I scale where the minimum is 16 (yoga group = 17.76 ± 2.76, control group = 17.32 ± 1.53). Therefore, with an average of age of 60.36 years old in the present sample (yoga group = 61.12 ± 4.15, control group = 59.60 ± 2.99), this group should show minimal risk of falling according to up-to-date literature on falls prevention in older age.

Yoga Practitioner Univariate Analysis of Variance. The final finding that needs to be addressed is the non-significant univariate analysis of variance within the yoga group. Individuals were divided into groups according to their age, years of yoga experience, and the number of types of yoga the individual practiced on a regular basis. These variables did not significantly affect BESTest total scores or FES-I scores. As a result, no conclusion can be made as to how long an individual must practice before improvements in the balance score can be seen. Due to the lack of previous research on this topic of habituality in the yoga practitioner, we are unable to compare this information with previous literature.

The shortest amount of time an individual had been practicing prior to engaging in the present study was five months while the longest an individual had been practicing was twenty years. Therefore, without a significant difference in the balance score between an individual who has been practicing five months and an individual who has been practicing 20 years, it is apparent that you can develop balance benefits within five months that are equivalent to the benefits seen after 20 years of practice. Further suggesting that yoga is a beneficial activity to participate in that is low-intensity, low-impact, and relatively easy to start at any age.

Summary and Conclusion. In summary, the yoga practitioner group performed 5.2% better on the BESTest than the control group without having different reported daily activity levels between groups, as shown by the insignificant difference between the group's GPAQ results. The improvement in balance scores has yet to affect the falling statistics of the two groups due to their age and associated low risk of falling. According to previous literature on aging and balance, the 5.2% higher balance score could result in fewer unintentional falls as the subjects' age associated risk of falling increases. The lack of relationship between years dedicated to the practice and balance scores suggests that an individual can begin a habitual practice of yoga at any age between 55 and 70 years old and reap the benefits of the yoga practice through improved balance scores. In conclusion, the habitual practice of yoga alters balance measures and associated fall risks. Consequently, the practice of yoga is justified as a preventative measure for unintentional falls in adults.

Chapter 5

SUMMARY, FINDINGS, CONCLUSIONS, IMPLEMENTATIONS, AND RECOMMENDATIONS

Summary

The problem of this study was to examine differences in biomechanical constraints, stability limits, postural responses, anticipatory postural adjustments, sensory orientation, and stability in gait in habitual adult yoga practitioners and healthy adults. Included in the study was an attempt to identify whether or not the habitual practice of yoga alters balance measures and associated fall risks.

The subjects of the study were 40 individuals between the ages of 55 and 70 years old who had either claimed they did or did not habitually practice yoga during the winter of 2015 and spring of 2016. All subjects completed a survey instrument consisting of the Falls Self-Efficacy Scale – International, unintentional fall history, physical activity readiness questionnaire, yoga history questionnaire, and questions designed to determine demographic data and neurological health. Once the survey was complete and the subject was deemed eligible, they were asked to complete an in-person activity questionnaire (GPAQ) and balance assessment called the Balance Evaluation Systems Test (BESTest). The data for the study were collected during the months of January-March, 2016.

The data were analyzed using two statistical techniques. Independent group t-test was used to test the differences in age, sex, height, weight, BESTest total score, BESTest section scores, estimated metabolic equivalences, FES-I total score, and the number of unintentional falls in the past 12 months. Univariate analysis of variance was used to determine if the independent variables of age, years of practicing yoga, and the number of different types of yoga an individual practices could significantly predict the dependent variables of BESTest total score ore FES-I total score. The Statistical Package for the Social Sciences (SPSS) was used for all statistical analysis.

Findings

The analysis of the data revealed the following significant findings:

1. The BESTest total score was significantly higher in the habitual yoga practitioners when compared to healthy controls.
2. The sections of the BESTest that tested biomechanical constraints, transitions/anticipatory postural adjustments, sensory orientation, and stability in gait were significantly higher in the habitual yoga practitioners when compared to healthy controls.
3. The demographic data of age, sex, height, and weight were not significantly different between the habitual yoga practitioners and the healthy controls.
4. Daily activity levels were not significantly different between the habitual yoga practitioners and the healthy controls.
5. FES-I total score and number of falls in the past 12 months were not significantly different between the habitual yoga practitioners and the healthy controls.

Conclusions

Within the limitations of the study, the following conclusions are warranted:

1. Significant balance differences exist between habitual yoga practitioners and healthy controls, specifically biomechanical constraints, transitions/anticipatory postural adjustments, sensory orientation, and stability in gait.

2. 55-70 years old is too young of an age range to see significant differences in fear of falling and number of unintentional falls.

Implementations

The findings of the study may be implemented into either a professional practice situation or a research setting in the following ways:

1. The significance of balance scores to discriminate between habitual yoga practitioners and healthy controls should be considered when developing exercise programs to prevent unintentional falls among the aging population. The use of yoga three times or more per week may help to prevent the decline in balance scores seen with increases in age and frailty.
2. Yoga is a low-intensity, low-impact activity that can be easily implemented into an aging or frail individual's routine to improve a variety of balance scores. The type and duration of the yoga practice may differ, but the habitual practice of yoga could slow the passive decrements in balance seen with aging as a protective mechanism.

Recommendations for Further Study

The following recommendations are made for further research in the area of balance with respect to habitually practicing yoga:

1. The relationship between duration of yoga practice (in terms of years as well as times practiced per week) and balance scores should be examined further with a larger sample size.
2. The relationship between type of yoga practiced and balance scores should be

examined further with a larger sample size.

3. The present study should be replicated using both older and younger populations.
4. A study should be conducted to determine the cause of yoga's influence on balance scores. This could include looking at chronic reductions in reflex sensitivity that may occur with habitual yoga practices that induce repeated passive stretching.

REFERENCES

1. Prevention CfDCa. Falls Among Older Adults: An Overview. In: Falls Among Older Adults. http://www.cdc.gov: Centers for Disease Control and Prevention; 2015.
2. Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. Injury prevention 2006;12(5):290-295.
3. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age and ageing 2006;35(suppl 2):ii7-ii11.
4. Horak FB, Shupert CL, Mirka A. Components of postural dyscontrol in the elderly: a review. Neurobiology of aging 1989;10(6):727-738.
5. Field T. Yoga clinical research review. Complement Ther Clin Pract 2011;17(1):1-8.
6. Jones. Yoga as an Effective Falls Prevention Method for Seniors. In: Brunswick UoN, editor.
7. Avela J, Kyröläinen H, Komi PV. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. Journal of Applied Physiology 1999;86(4):1283-1291.
8. Saper RB, Eisenberg DM, Davis RB, Culpepper L, Phillips RS. Prevalence and patterns of adult yoga use in the United States: results of a national survey. Alternative therapies in health and medicine 2003;10(2):44-49.
9. Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. The journal of alternative and complementary medicine 2010;16(1):3-12.
10. Oken BS, Zajdel D, Kishiyama S, Flegal K, Dehen C, Haas M, et al. Randomized, controlled, six-month trial of yoga in healthy seniors: effects on cognition and quality of life. Alternative therapies in health and medicine 2006;12(1):40.
11. Horak FW, D.M., Frank, J. The Balance Evaluation Systems Test (BESTest) to Differentiate Balance Deficits. Phys Ther 2009;89(5):484-489.
12. Lanska DJ. The Romberg sign and early instruments for measuring postural sway. In: Seminars in neurology; 2002: [New York]: Thieme-Stratton Inc.,[c1981-; 2002. p. 409-418.
13. Shumway-Cook A, Horak FB. Assessing the influence of sensory interaction on balance suggestion from the field. Physical Therapy 1986;66(10):1548-1550.
14. Taube W, Gruber M, Gollhofer A. Spinal and supraspinal adaptations associated with balance training and their functional relevance. Acta Physiol (Oxf) 2008;193(2):101-16.
15. Lord SR, Clark RD, Webster IW. Physiological factors associated with falls in an elderly population. Journal of the American Geriatrics Society 1991;39(12):1194-1200.
16. Belal A, Glorig A. Dysequilibrium of ageing (presbyastasis). The Journal of Laryngology & Otology 1986;100(09):1037-1041.
17. Fukagawa NK, Wolfson L, Judge J, Whipple R, King M. Strength is a major factor in balance, gait, and the occurrence of falls. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 1995;50(Special Issue):64-67.
18. Vandervoort A. Effects of ageing on human neuromuscular function: implications for exercise. Canadian journal of sport sciences= Journal canadien des sciences du sport 1992;17(3):178-184.

19. Desforges JF, Tinetti ME, Speechley M. Prevention of falls among the elderly. New England Journal of Medicine 1989;320(16):1055-1059.
20. Moyer VA. Prevention of falls in community-dwelling older adults: US Preventive Services Task Force recommendation statement. Annals of Internal Medicine 2012;157(3):197-204.
21. Fletcher GF, Balady G, Blair SN, Blumenthal J, Caspersen C, Chaitman B, et al. Statement on exercise: Benefits and recommendations for physical activity programs for all Americans a statement for health professionals by the committee on exercise and cardiac rehabilitation of the council on clinical cardiology, American heart association. Circulation 1996;94(4):857-862.
22. Robertson MC, Campbell AJ, Gardner MM, Devlin N. Preventing injuries in older people by preventing falls: A meta‐analysis of individual‐level data. Journal of the American Geriatrics Society 2002;50(5):905-911.
23. Hu M-H, Woollacott MH. Multisensory training of standing balance in older adults: II. Kinematic and electromyographic postural responses. Journal of Gerontology 1994;49(2):M62-M71.
24. Wong AM, Chou S-W, Huang S-C, Lan C, Chen H-C, Hong W-H, et al. Does different exercise have the same effect of health promotion for the elderly? Comparison of training-specific effect of Tai Chi and swimming on motor control. Archives of gerontology and geriatrics 2011;53(2):e133-e137.
25. Lesinski M, Hortobágyi T, Muehlbauer T, Gollhofer A, Granacher U. Effects of Balance Training on Balance Performance in Healthy Older Adults: A Systematic Review and Meta-analysis. Sports Medicine 2015:1-18.
26. Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu T. Reducing frailty and falls in older persons: an investigation of Tai Chi and computerized balance training. Journal of the American Geriatrics Society 1996;44(5):489-497.
27. Kuramoto AM. Therapeutic benefits of Tai Chi exercise: research review. WMJ-MADISON- 2006;105(7):42.
28. Hain TC, Fuller L, Weil L, Kotsias J. Effects of T'ai Chi on balance. Archives of Otolaryngology–Head & Neck Surgery 1999;125(11):1191-1195.
29. Jacobson BH, HO-CHENG C, Cashel C, Guerrero L. The effect of T'ai Chi Chuan training on balance, kinesthetic sense, and strength. Perceptual and motor skills 1997;84(1):27-33.
30. Perrin PP, Gauchard GC, Perrot C, Jeandel C. Effects of physical and sporting activities on balance control in elderly people. British journal of sports medicine 1999;33(2):121-126.
31. Hu M-H, Woollacott MH. Multisensory training of standing balance in older adults: I. Postural stability and one-leg stance balance. Journal of gerontology 1994;49(2):M52-M61.
32. Brisbon NM, Lowery GA. Mindfulness and levels of stress: a comparison of beginner and advanced hatha yoga practitioners. Journal of religion and health 2011;50(4):931-941.
33. Shelov DV, Suchday S, Friedberg JP. A pilot study measuring the impact of yoga on the trait of mindfulness. Behavioural and cognitive psychotherapy 2009;37(05):595-598.

34. Hartfiel N, Havenhand J, Khalsa SB, Clarke G, Krayer A. The effectiveness of yoga for the improvement of well-being and resilience to stress in the workplace. Scandinavian journal of work, environment & health 2011:70-76.
35. Cowen VS. Functional fitness improvements after a worksite-based yoga initiative. Journal of bodywork and movement therapies 2010;14(1):50-54.
36. Michalsen A, Grossman P, Acil A, Langhorst J, Lüdtke R, Esch T, et al. Rapid stress reduction and anxiolysis among distressed women as a consequenceof a three-month intensive yoga program. American Journal of Case Reports 2005;11(12):CR555-CR561.
37. Telles S, Gaur V, Balkrishna A. Effect of a yoga practice session and a yoga theory session on state anxiety 1. Perceptual and motor skills 2009;109(3):924-930.
38. Khumar S, Kaur P, Kaur S. Effectiveness of Shavasana on depression among university students. Indian Journal of Clinical Psychology 1993.
39. Uebelacker LA, Tremont G, Epstein-Lubow G, Gaudiano BA, Gillette T, Kalibatseva Z, et al. Open trial of Vinyasa yoga for persistently depressed individuals: evidence of feasibility and acceptability. Behavior Modification 2010.
40. Kamei T, Toriumi Y, Kimura H, Ohno S, Kumano H, Kimura K. Decrease in serum cortisol during yoga exercise is correlated with alpha wave activation. Perceptual and motor skills 2000;90(3):1027-1032.
41. Khalsa SBS. Treatment of chronic insomnia with yoga: a preliminary study with sleep–wake diaries. Applied psychophysiology and biofeedback 2004;29(4):269-278.
42. Manjunath N, Telles S. Influence of Yoga & Ayurveda on self-rated sleep in a geriatric population. Indian Journal of Medical Research 2005;121(5):683.
43. Field T, Diego M, Cullen C, Hernandez-Reif M, Sunshine W, Douglas S. Fibromyalgia pain and substance P decrease and sleep improves after massage therapy. JCR: Journal of Clinical Rheumatology 2002;8(2):72-76.
44. Sherman KJ, Cherkin DC, Erro J, Miglioretti DL, Deyo RA. Comparing yoga, exercise, and a self-care book for chronic low back pain: a randomized, controlled trial. Annals of Internal Medicine 2005;143(12):849-856.
45. Saper RB, Sherman KJ, Cullum-Dugan D, Davis RB, Phillips RS, Culpepper L. Yoga for chronic low back pain in a predominantly minority population: a pilot randomized controlled trial. Alternative therapies in health and medicine 2009;15(6):18.
46. Williams KA, Petronis J, Smith D, Goodrich D, Wu J, Ravi N, et al. Effect of Iyengar yoga therapy for chronic low back pain. Pain 2005;115(1):107-117.
47. John P, Sharma N, Sharma CM, Kankane A. Effectiveness of yoga therapy in the treatment of migraine without aura: a randomized controlled trial. Headache: The Journal of Head and Face Pain 2007;47(5):654-661.
48. Garfinkel MS, Schumacher Jr HR, Husain A, Levy M, Reshetar R. Evaluation of a yoga based regimen for treatment of osteoarthritis of the hands. The Journal of rheumatology 1994;21(12):2341-2343.
49. Kolasinski SL, Garfinkel M, Tsai AG, Matz W, Dyke AV, Schumacher Jr HR. Iyengar yoga for treating symptoms of osteoarthritis of the knees: a pilot study. Journal of Alternative & Complementary Medicine 2005;11(4):689-693.

50. Evans S, Moieni M, Taub R, Subramanian SK, Tsao JC, Sternlieb B, et al. Iyengar yoga for young adults with rheumatoid arthritis: results from a mixed-methods pilot study. Journal of Pain and Symptom Management 2010;39(5):904-913.
51. Yogendra J, Yogendra H, Ambardekar S, Leie R, Shetty S, Dave M. Beneficial effects of yoga lifestyle on reversibility of ischaemic heart disease: caring heart project of International Board of Yoga. JAPI 2004;52:283-9.
52. Manchanda S, Narang R, Reddy K, Sachdeva U, Prabhakaran D, Dharmanand S, et al. Retardation of coronary atherosclerosis with yoga lifestyle intervention. The Journal of the Association of Physicians of India 2000;48(7):687-694.
53. Pullen PR, Thompson WR, Benardot D, Brandon LJ, Mehta PK, Rifai L, et al. Benefits of yoga for African American heart failure patients. Med Sci Sports Exerc 2010;42(4):651-657.
54. Damodaran A, Malathi A, Patil N, Shah N, Marathe S. Therapeutic potential of yoga practices in modifying cardiovascular risk profile in middle aged men and women. The Journal of the Association of Physicians of India 2002;50(5):633-640.
55. Cade W, Reeds DN, Mondy KE, Overton E, Grassino J, Tucker S, et al. Yoga lifestyle intervention reduces blood pressure in HIV - infected adults with cardiovascular disease risk factors*. HIV medicine 2010;11(6):379-388.
56. DiBenedetto M, Innes KE, Taylor AG, Rodeheaver PF, Boxer JA, Wright HJ, et al. Effect of a gentle Iyengar yoga program on gait in the elderly: an exploratory study. Archives of Physical Medicine and Rehabilitation 2005;86(9):1830-1837.
57. Manocha R, Marks G, Kenchington P, Peters D, Salome C. Sahaja yoga in the management of moderate to severe asthma: a randomised controlled trial. Thorax 2002;57(2):110-115.
58. Singh S, Malhotra V, Singh K, Madhu S, Tandon O. Role of yoga in modifying certain cardiovascular functions in type-2 diabetic patients. JAPI 2004;52:203-6.
59. Gordon LA, Morrison EY, McGrowder DA, Young R, Fraser YT, Zamora EM, et al. Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC complementary and alternative medicine 2008;8(1):21.
60. Cohen L, Warneke C, Fouladi RT, Rodriguez M, Chaoul - Reich A. Psychological adjustment and sleep quality in a randomized trial of the effects of a Tibetan yoga intervention in patients with lymphoma. Cancer 2004;100(10):2253-2260.
61. Rao MR, Raghuram N, Nagendra H, Gopinath K, Srinath B, Diwakar RB, et al. Anxiolytic effects of a yoga program in early breast cancer patients undergoing conventional treatment: a randomized controlled trial. Complementary therapies in medicine 2009;17(1):1-8.
62. Carson JW, Carson KM, Porter LS, Keefe FJ, Shaw H, Miller JM. Yoga for women with metastatic breast cancer: results from a pilot study. Journal of pain and symptom management 2007;33(3):331-341.
63. Harinath K, Malhotra AS, Pal K, Prasad R, Kumar R, Kain TC, et al. Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile, and melatonin secretion. The Journal of Alternative & Complementary Medicine 2004;10(2):261-268.

64. Chaya MS, Kurpad AV, Nagendra HR, Nagarathna R. The effect of long term combined yoga practice on the basal metabolic rate of healthy adults. BMC Complement Altern Med 2006;6:28.
65. Raub JA. Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: a literature review. The Journal of Alternative & Complementary Medicine 2002;8(6):797-812.
66. McIver S, McGartland M, O'Halloran P. "Overeating is Not About the Food": Women Describe Their Experience of a Yoga Treatment Program for Binge Eating. Qualitative health research 2009;19(9):1234-1245.
67. HEALTHY AWGI. Yoga practice is associated with attenuated weight gain in healthy, middle-aged men and women. Health Med 2005;11(4):28-33.
68. Telles S, Naveen VK, Balkrishna A, Kumar S. Short term health impact of a yoga and diet change program on obesity. Medical Science Review 2009;16(1):CR35-CR40.
69. Carei TR, Fyfe-Johnson AL, Breuner CC, Brown MA. Randomized controlled clinical trial of yoga in the treatment of eating disorders. Journal of Adolescent Health 2010;46(4):346-351.
70. Hart CE, Tracy BL. Yoga as steadiness training: effects on motor variability in young adults. The Journal of Strength & Conditioning Research 2008;22(5):1659-1669.
71. Chen K-M, Tseng W-S. Pilot-testing the effects of a newly-developed silver yoga exercise program for female seniors. Journal of Nursing Research 2008;16(1):37-46.
72. Grabara M, Szopa J. Habitual body posture and mountain position of people practising yoga. Biology of Sport 2011;28(1):51.
73. Ahmadi A, Nikbakh M, Arastoo A, Habibi A-H. The Effects of a Yoga Intervention on Balance, Speed and Endurance of Walking, Fatigue and Quality of Life in People with Multiple Sclerosis. Journal of Human Kinetics 2010;23(-1).
74. Ulger O, Yagli NV. Effects of yoga on balance and gait properties in women with musculoskeletal problems: a pilot study. Complement Ther Clin Pract 2011;17(1):13-5.
75. Schmid AA, Van Puymbroeck M, Koceja DM. Effect of a 12-week yoga intervention on fear of falling and balance in older adults: a pilot study. Arch Phys Med Rehabil 2010;91(4):576-83.
76. Horak F. Balance Evaluation - Systems Test. 2008.
77. Department PoND. Global Physical Activity Questionnaire (GPAQ). World Health Organization 2005.
78. (ProFaNE) PoFNE. FES - I English. 2005.
79. Raad J. Rehabilitation Measures Database: Balance Evaluation Systems Test. In. RehabilitationMeasures.org; 2012.
80. Dewan N, MacDermid JC. Fall Efficacy Scale - International (FES-I). Journal of Physiotherapy 2014;60(1):60.
81. Gothe N. The effects of an 8-week yoga intervention on cognition and functional fitness in older adults: University of Illinois at Urbana-Champaign; 2013.
82. Hakim RM, Kotroba E, Cours J, Teel S, Leininger PM. A Cross-Sectional Study of Balance-Related Measures with Older Adults Who Participated in Tai Chi, Yoga, or No Exercise. Physical & Occupational Therapy in Geriatrics 2010;28(1):63-74.
83. Jannati S, Sohrabi M, Attarzadeh Hoseini R. The effect of selective Hata yoga training on balance of elderly women. Iranian journal of ageing 2011;5(18):0-0.

84. Berger DL, Stein RE. Effects of yoga on inner-city children's well-being: a pilot study. Alternative Therapies in Health and Medicine 2009;15(5):36.
85. Organization WH. WHO Global Report on Falls Prevention in Older Age. France; 2007.

APPENDICES

Demographic and BESTest Raw Data

Subject	Group	Sex	Age	Height	Weight	EstMETs	Falls	Sitting	TOTAL_BESTest	PercentTotalScore
1	1	1	57.67	70.98	213.8	19920	0	1	100	0.93
2	2	2	55.97	59	142	1120	2	10	107	0.99
3	2	2	59.43	65.5	177.5	2160	1	8	101	0.94
4	1	1	63.39	71.3	182.7	12080	0	6	103	0.95
5	1	2	55.34	65.47	132.89	3480	4	3	105	0.97
6	1	2	60.87	64.06	164.56	2400	1	5	96	0.89
7	1	1	55.36	74.29	195.14	9240	0	3	105	0.97
8	1	1	65.85	71.38	174.56	3760	0	8	104	0.96
9	1	2	58.70	65	137.8	5400	0	6.5	108	1.00
10	1	1	60.07	68	171.7	5400	0	6	106	0.98
11	2	2	64.35	65	152.2	4800	0	4	98	0.91
12	2	2	63.64	63	181.2	540	1	7	95	0.88
13	2	2	55.11	64	157.4	0	0	10	91	0.84
14	2	1	55.37	74	203.9	8880	12	5	93	0.86
15	2	2	61.40	65.5	148.6	2040	0	7	104	0.96
16	2	2	56.56	61	117.1	540	0	8	99	0.92
17	2	1	57.52	70	172	15120	0	2	99	0.92
18	2	1	60.72	70	182.6	9000	0	3	97	0.90
19	2	1	58.11	68	223	0	0	12	94	0.87
20	2	2	57.88	63	216.5	0	0	10	93	0.86
21	2	1	58.31	66	200.5	3360	0	5	97	0.90
22	2	2	59.75	62	126.59	2000	0	13	95	0.88
23	2	1	61.36	62.76	153.68	1320	1	10	92	0.85
24	2	2	62.46	64.33	151.77	9000	0	8	92	0.85
25	1	2	60.66	64	174.2	1680	0	3.5	100	0.93
26	1	2	55.76	62	119	6960	1	5	96	0.89
27	2	1	62.48	66	185.4	7980	0	8	101	0.94
28	2	2	57.59	65.62	261.05	1220	1	8.5	94	0.87
29	2	1	64.42	67.03	144.4	3360	0	4	93	0.86
30	1	2	60.87	69.72	151.1	7680	0	2.5	105	0.97
31	1	2	65.35	67	126.5	4020	0	5.5	102	0.94
32	1	2	56.38	65	204	2220	0	10	103	0.95
33	1	1	65.31	71	164	1680	0	7	103	0.95
34	1	2	62.71	65	113	11280	0	2	106	0.98
35	1	2	70.96	62	155.4	5160	0	7	103	0.95
36	1	1	66.22	73	224.6	1320	0	6.5	102	0.94
37	1	1	63.52	68	164.6	2880	0	11	101	0.94
38	1	2	60.01	66	138.8	4520	7	4	92	0.85
39	1	2	60.89	67	155.9	14440	0	5	102	0.94
40	1	2	57.60	66.5	128.3	2400	0	3.5	105	0.97

Demographic and BESTest Raw Data - Continued

Subject	SECTION_I	SECTION_II	SECTION_III	SECTION_IV	SECTION_V	SECTION_VI
1	14	21	17	15	15	18
2	14	21	18	18	15	21
3	13	21	18	16	15	18
4	15	19	18	16	15	20
5	14	21	17	17	15	21
6	14	18	18	13	15	18
7	15	19	18	18	15	20
8	13	20	18	18	15	20
9	15	21	18	18	15	21
10	14	21	18	18	15	20
11	14	21	16	17	12	18
12	12	20	16	14	14	19
13	13	19	16	13	13	17
14	13	20	14	13	14	19
15	15	21	17	16	15	20
16	14	20	16	15	14	20
17	12	21	18	16	13	19
18	12	19	16	16	15	19
19	12	18	15	17	15	17
20	13	20	15	15	14	16
21	12	21	17	14	14	19
22	14	19	16	16	14	16
23	12	20	15	15	11	19
24	13	20	16	14	13	16
25	13	21	15	17	14	20
26	15	19	18	11	15	18
27	13	21	17	16	15	19
28	13	20	16	13	14	18
29	13	21	14	13	14	18
30	14	21	18	16	15	21
31	15	21	17	15	14	20
32	14	21	18	15	15	20
33	15	20	17	17	14	20
34	15	21	18	17	15	20
35	13	21	18	16	15	20
36	14	21	14	18	15	20
37	13	21	16	17	15	19
38	12	18	15	14	14	19
39	13	21	18	16	15	19
40	14	21	18	17	15	20

<u>Yoga Practitioner Data</u>

Subject	Yoga_years	Yoga_days/wk	Yoga_Hours	Yoga_hrs/wk
1	3.5	7	0.17	1.17
2	0	0	0.00	0.00
3	0	0	0.00	0.00
4	1.5	5	1.00	5.00
5	4	5	1.00	5.00
6	0.096	3	1.50	4.50
7	4	5	1.00	5.00
8	20	5	1.00	5.00
9	4	1	1.50	1.50
10	4	1	1.50	1.50
11	0	0	0.00	0.00
12	0	0	0.00	0.00
13	0	0	0.00	0.00
14	0	0	0.00	0.00
15	0	0	0.00	0.00
16	0	0	0.00	0.00
17	0	0	0.00	0.00
18	0	0	0.00	0.00
19	0	0	0.00	0.00
20	0	0	0.00	0.00
21	0	0	0.00	0.00
22	0	0	0.00	0.00
23	0	0	0.00	0.00
24	0	0	0.00	0.00
25	5	1	1.75	1.75
26	5	3	1.25	3.75
27	0	0	0.00	0.00
28	0	0	0.00	0.00
29	0	0	0.00	0.00
30	0.5	4	1.00	4.00
31	13	3	1.00	3.00
32	2	3	1.00	3.00
33	7	6	0.75	4.50
34	14	6	2.00	12.00
35	7	4	0.50	2.00
36	4	5	1.00	5.00
37	0.38	2	1.17	2.33
38	4	4	1.00	4.00
39	12	3	1.00	3.00
40	9	5	1.50	7.50

<u>GPAQ Data</u>

Subject	Group	Height (in.)	Weight (lbs.)	Est. METs	Vigorous Work			Moderate Work		
1	Y	70.98	213.8	19920	1	4	360	1	7	240
2	C	59	142	1120	2	0	0	1	7	20
3	C	65.5	177.5	2160	2	0	0	1	1	60
4	Y	71.3	182.7	12080	2	0	0	1	6	360
5	Y	65.47	132.89	3480	2	0	0	1	5	30
6	Y	64.06	164.56	2400	2	0	0	1	3	120
7	Y	74.29	195.14	9240	2	0	0	1	7	60
8	Y	71.38	174.56	3760	2	0	0	1	4	60
9	Y	65	137.8	5400	2	0	0	1	1	210
10	Y	68	171.7	5400	2	0	0	1	2	180
11	C	65	152.2	4800	2	0	0	1	6	120
12	C	63	181.2	540	2	0	0	2	0	0
13	C	64	157.4	0	2	0	0	2	0	0
14	C	74	203.9	8880	1	5	60	1	6	240
15	C	65.5	148.6	2040	2	0	0	2	0	0
16	C	61	117.1	540	2	0	0	2	0	0
17	C	70	172	15120	2	0	0	1	7	420
18	C	70	182.6	9000	1	5	120	1	7	120
19	C	68	223	0	2	0	0	2	0	0
20	C	63	216.5	0	2	0	0	2	0	0
21	C	66	200.5	3360	2	0	0	2	0	0
22	C	62	126.59	2000	2	0	0	2	0	0
23	C	62.76	153.68	1320	2	0	0	2	0	0
24	C	64.33	151.77	9000	2	0	0	1	7	300
25	Y	64	174.2	1680	2	0	0	1	2	120
26	Y	62	119	6960	2	0	0	1	7	120
27	C	66	185.4	7980	1	2	240	1	5	180
28	C	65.62	261.05	1220	1	1	30	1	1	45
29	C	67.03	144.4	3360	2	0	0	2	0	0
30	Y	69.72	151.1	7680	1	5	60	1	6	180
31	Y	67	126.5	4020	2	0	0	1	7	60
32	Y	65	204	2220	2	0	0	2	0	0
33	Y	71	164	1680	2	0	0	2	0	0
34	Y	65	113	11280	1	7	60	1	7	180
35	Y	62	155.4	5160	2	0	0	1	7	150
36	Y	73	224.6	1320	2	0	0	2	0	0
37	Y	68	164.6	2880	2	0	0	2	0	0
38	Y	66	138.8	4520	2	0	0	1	5	30
39	Y	67	155.9	14440	1	5	120	1	7	270
40	Y	66.5	128.3	2400	2	0	0	2	0	0

GPAQ Data - Continued

Subject	Travel		Vigorous Recreation			Moderate Recreation				Sitting (hr.)
1	2	0	0	2	0	0	1	7	60	1
2	2	0	0	2	0	0	1	7	20	10
3	1	4	60	2	0	0	1	4	60	8
4	1	7	60	1	2	20	1	6	60	6
5	2	0	0	1	3	50	1	7	60	3
6	2	0	0	2	0	0	1	4	60	5
7	1	7	20	1	7	65	1	7	120	3
8	1	4	40	1	2	60	1	5	60	8
9	2	0	0	1	5	90	1	4	60	6.5
10	2	0	0	1	5	90	1	3	30	6
11	2	0	0	2	0	0	1	4	120	4
12	2	0	0	2	0	0	1	3	45	7
13	2	0	0	2	0	0	2	0	0	10
14	2	0	0	2	0	0	1	3	60	5
15	2	0	0	1	5	36	1	5	30	7
16	2	0	0	2	0	0	1	3	45	8
17	1	7	120	2	0	0	2	0	0	2
18	2	0	0	2	0	0	1	7	30	3
19	2	0	0	2	0	0	2	0	0	12
20	2	0	0	2	0	0	2	0	0	10
21	2	0	0	1	4	90	1	2	60	5
22	1	6	20	1	5	20	1	2	90	13
23	2	0	0	1	3	25	1	6	30	10
24	2	0	0	2	0	0	1	5	30	8
25	2	0	0	2	0	0	1	3	60	3.5
26	2	0	0	1	5	60	1	5	60	5
27	2	0	0	2	0	0	1	3	45	8
28	1	5	40	2	0	0	2	0	0	8.5
29	1	7	40	1	7	20	1	7	40	4
30	2	0	0	2	0	0	1	4	60	2.5
31	2	0	0	1	3	60	1	3	75	5.5
32	2	0	0	1	3	60	1	3	65	10
33	2	0	0	1	3	30	1	4	60	7
34	2	0	0	1	4	60	1	4	60	2
35	2	0	0	2	0	0	1	4	60	7
36	2	0	0	1	3	30	1	2	75	6.5
37	2	0	0	1	3	120	2	0	0	11
38	2	0	0	1	7	40	1	7	60	4
39	1	4	40	2	0	0	1	6	60	5
40	2	0	0	2	0	0	1	5	120	3.5

FES-I Data

Subject	FES-I Total	Cleaning the house (e.g. sweep, vacuum, dust)	Getting dressed or undressed	Preparing simple meals	Taking a bath or shower	Going to the shop
1	16	1	1	1	1	1
2	18	1	1	1	1	1
3	19	1	1	1	1	1
4	17	1	1	1	1	1
5	21	2	2	1	1	1
6	17	1	1	1	1	1
7	16	1	1	1	1	1
8	17	1	1	1	1	1
9	16	1	1	1	1	1
10	17	1	1	1	1	1
11	18	1	1	1	1	1
12	18	1	1	1	1	1
13	17	1	1	1	1	1
14	22	1	1	1	2	1
15	16	1	1	1	1	1
16	16	1	1	1	1	1
17	16	1	1	1	1	1
18	16	1	1	1	1	1
19	17	1	1	1	1	1
20	18	1	1	1	1	1

<u>FES-I Data - Continued</u>

Subject	FES-I Total	Cleaning the house (e.g. sweep, vacuum, dust)	Getting dressed or undressed	Preparing simple meals	Taking a bath or shower	Going to the shop
21	19	1	1	1	1	1
22	16	1	1	1	1	1
23	17	1	1	1	1	1
24	16	1	1	1	1	1
25	16	1	1	1	1	1
26	16	1	1	1	1	1
27	17	1	1	1	1	1
28	17	1	1	1	1	1
29	16	1	1	1	1	1
30	20	1	1	1	1	1
31	16	1	1	1	1	1
32	18	1	1	1	1	1
33	18	1	1	1	1	1
34	16	1	1	1	1	1
35	17	1	1	1	1	1
36	17	1	1	1	1	1
37	17	1	1	1	1	1
38	28	1	1	1	1	1
39	17	1	1	1	1	1
40	20	1	2	1	1	1

FES-I Data – Continued

Subject	Going up or down stairs	Walking around in the neighborhood	Reaching for something above your head or on the ground	Going to answer the telephone before it stops ringing
1	1	1	1	1
2	1	1	1	1
3	1	1	1	1
4	1	1	1	1
5	2	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12	1	1	1	1
13	1	1	1	1
14	2	1	1	1
15	1	1	1	1
16	1	1	1	1
17	1	1	1	1
18	1	1	1	1
19	1	1	1	1
20	1	1	1	1

FES-I Data – Continued

Subject	Going up or down stairs	Walking around in the neighborhood	Reaching for something above your head or on the ground	Going to answer the telephone before it stops ringing
21	2	1	1	1
22	1	1	1	1
23	1	1	1	1
24	1	1	1	1
25	1	1	1	1
26	1	1	1	1
27	1	1	1	1
28	1	1	1	1
29	1	1	1	1
30	1	1	1	1
31	1	1	1	1
32	1	1	1	1
33	1	1	1	1
34	1	1	1	1
35	1	1	1	1
36	1	1	1	1
37	1	1	1	1
38	2	2	2	1
39	1	1	1	1
40	1	1	1	1

FES-I Data – Continued

Subject	Getting in or out of a chair	Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)	Walking up or down a slope	Walking on a slippery surface (e.g. wet or icy)
1	1	1	1	1
2	1	1	1	3
3	1	2	2	2
4	1	1	1	2
5	1	1	2	2
6	1	1	1	2
7	1	1	1	1
8	1	1	1	2
9	1	1	1	1
10	1	1	1	2
11	1	2	1	2
12	1	2	1	2
13	1	1	1	2
14	1	2	2	2
15	1	1	1	1
16	1	1	1	1
17	1	1	1	1
18	1	1	1	1
19	1	1	1	2
20	1	2	1	2

FES-I Data – Continued

Subject	Getting in or out of a chair	Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)	Walking up or down a slope	Walking on a slippery surface (e.g. wet or icy)
21	1	2	1	2
22	1	1	1	1
23	1	1	1	2
24	1	1	1	1
25	1	1	1	1
26	1	1	1	1
27	1	2	1	1
28	1	1	1	2
29	1	1	1	1
30	1	2	2	3
31	1	1	1	1
32	1	2	1	2
33	1	2	1	2
34	1	1	1	1
35	1	1	1	2
36	1	1	1	1
37	1	1	1	2
38	2	3	2	4
39	1	1	1	2
40	1	2	1	2

FES-I Data – Continued

Subject	Going out to a social event (e.g. religious service, family gathering, or club meeting)	Visiting a friend or relative	Walking in a place with crowds
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
13	1	1	1
14	2	1	1
15	1	1	1
16	1	1	1
17	1	1	1
18	1	1	1
19	1	1	1
20	1	1	1

FES-I Data – Continued

Subject	Going out to a social event (e.g. religious service, family gathering, or club meeting)	Visiting a friend or relative	Walking in a place with crowds
21	1	1	1
22	1	1	1
23	1	1	1
24	1	1	1
25	1	1	1
26	1	1	1
27	1	1	1
28	1	1	1
29	1	1	1
30	1	1	1
31	1	1	1
32	1	1	1
33	1	1	1
34	1	1	1
35	1	1	1
36	2	1	1
37	1	1	1
38	2	1	2
39	1	1	1
40	1	1	2

Independent Groups t-test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Sex	1.00	21	1.6190	.49761	.10859
	2.00	19	1.5789	.50726	.11637
Age	1.00	21	61.1186	4.15184	.90601
	2.00	19	59.6016	2.99921	.68807
Height	1.00	21	67.4619	3.51291	.76658
	2.00	19	65.3547	3.49667	.80219
Weight	1.00	21	161.5500	30.92191	6.74771
	2.00	19	173.5468	36.00759	8.26071
Totalscore_percent	1.00	21	94.6643	3.53608	.77164
	2.00	19	89.4253	4.06284	.93208
Section_I	1.00	21	14.0000	.89443	.19518
	2.00	19	13.0000	.88192	.20233
Section_II	1.00	21	20.3333	1.06458	.23231
	2.00	19	20.1579	.89834	.20609
Section_III	1.00	21	17.2381	1.22085	.26641
	2.00	19	16.1053	1.19697	.27460
Section_IV	1.00	21	16.1429	1.82444	.39812
	2.00	19	15.1053	1.52369	.34956
Section_V	1.00	21	14.8095	.40237	.08781
	2.00	19	13.8947	1.10024	.25241
Section_VI	1.00	21	19.7143	.90238	.19691
	2.00	19	18.3158	1.41628	.32492
EstMETs	1.00	21	6091.4286	4857.90725	1060.08227
	2.00	19	3812.6316	4219.51135	968.02229
Falls	1.00	21	.6190	1.71686	.37465
	2.00	19	.9474	2.73808	.62816
FOF_Total	1.00	21	17.7619	2.75508	.60121
	2.00	19	17.3158	1.52944	.35088

Independent Groups t-test – Continued

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Sex	.241	.626	.252	38	.802	.04010	.15901	-.28180	.36200
			.252	37.443	.802	.04010	.15917	-.28227	.36247
Age	1.267	.267	1.312	38	.197	1.51699	1.15615	-.82351	3.85750
			1.333	36.305	.191	1.51699	1.13766	-.78962	3.82361
Height	.308	.582	1.899	38	.065	2.10717	1.10984	-.13958	4.35392
			1.899	37.637	.065	2.10717	1.10958	-.13976	4.35410
Weight	.402	.530	-1.133	38	.264	-11.99684	10.58394	-33.42291	9.42923
			-1.125	35.721	.268	-11.99684	10.66634	-33.63506	9.64137
BESTest Percent	.978	.329	4.360	38	.000	5.23902	1.20150	2.80671	7.67133
			4.330	35.936	.000	5.23902	1.21004	2.78480	7.69325
Section_I	.036	.851	3.555	38	.001	1.00000	.28133	.43048	1.56952
			3.557	37.703	.001	1.00000	.28112	.43075	1.56925
Section_II	1.109	.299	.560	38	.579	.17544	.31324	-.45869	.80957
			.565	37.832	.575	.17544	.31055	-.45333	.80421
Section_III	.067	.798	2.958	38	.005	1.13283	.38299	.35751	1.90815
			2.961	37.740	.005	1.13283	.38260	.35812	1.90754
Section_IV	.111	.741	1.941	38	.060	1.03759	.53467	-.04479	2.11998
			1.958	37.777	.058	1.03759	.52981	-.03515	2.11034
Section_V	7.694	.009	3.560	38	.001	.91479	.25696	.39460	1.43497
			3.423	22.326	.002	.91479	.26725	.36102	1.46856
Section_VI	4.327	.044	3.762	38	.001	1.39850	.37177	.64588	2.15112
			3.681	30.008	.001	1.39850	.37993	.62258	2.17441
EstMETs	.163	.689	1.576	38	.123	2278.79699	1445.90924	-648.29324	5205.88723
			1.587	37.945	.121	2278.79699	1435.56316	-627.48664	5185.08062
Falls	.233	.632	-.459	38	.649	-.32832	.71522	-1.77621	1.11957
			-.449	29.701	.657	-.32832	.73140	-1.82267	1.16603
FOF_Total	1.389	.246	.624	38	.537	.44612	.71525	-1.00183	1.89406
			.641	31.840	.526	.44612	.69611	-.97209	1.86432

Univariate Analysis of Variance

Between-Subjects Factors

		N
YogaYears_Group	1.00	3
	2.00	11
	3.00	7
Age_Group	1.00	7
	2.00	9
	3.00	5
Types_Group	1.00	8
	2.00	6
	3.00	7

- Yoga Years
  - 0-1 = 1
  - 1.1-5 = 2
  - >5 years = 3
- Age Group
  - 55-60 = 1
  - 60.01-65 = 2
  - >65 = 3
- Types of Yoga
  - 1 type = 1
  - 2 types = 2
  - >2 types = 3

BESTest Total Score as DV

Tests of Between-Subjects Effects

Dependent Variable: Total_BESTest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	105.815[a]	12	8.818	.489	.873
Intercept	138833.844	1	138833.844	7699.004	.000
YogaYears_Group	8.103	2	4.052	.225	.804
Age_Group	9.243	2	4.622	.256	.780
Types_Group	9.441	2	4.721	.262	.776
YogaYears_Group * Age_Group	.000	0	.	.	.
YogaYears_Group * Types_Group	.000	0	.	.	.
Age_Group * Types_Group	30.870	1	30.870	1.712	.227
YogaYears_Group * Age_Group * Types_Group	.000	0	.	.	.
Error	144.262	8	18.033		
Total	188437.944	21			
Corrected Total	250.077	20			

BESTest Total Score as DV - Continued

Multiple Comparisons

Dependent Variable: Total_BESTest

Tukey HSD

(I) YogaYears_Group	(J) YogaYears_ Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.07	2.766	.922	-8.97	6.84
	3.00	-2.69	2.930	.645	-11.06	5.68
2.00	1.00	1.07	2.766	.922	-6.84	8.97
	3.00	-1.62	2.053	.719	-7.49	4.24
3.00	1.00	2.69	2.930	.645	-5.68	11.06
	2.00	1.62	2.053	.719	-4.24	7.49

Based on observed means.

The error term is Mean Square(Error) = 18.033.

Multiple Comparisons

Dependent Variable: Total_BESTest

Tukey HSD

(I) Age_Group	(J) Age_Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	1.78	2.140	.696	-4.34	7.89
	3.00	.32	2.486	.991	-6.79	7.42
2.00	1.00	-1.78	2.140	.696	-7.89	4.34
	3.00	-1.46	2.369	.816	-8.23	5.31
3.00	1.00	-.32	2.486	.991	-7.42	6.79
	2.00	1.46	2.369	.816	-5.31	8.23

Based on observed means.

The error term is Mean Square(Error) = 18.033.

BESTest Total Score as DV - Continued

Multiple Comparisons

Dependent Variable: Total_BESTest

Tukey HSD

(I) Types_Group	(J) Types_Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-2.08	2.293	.651	-8.63	4.47
	3.00	-.96	2.198	.902	-7.24	5.32
2.00	1.00	2.08	2.293	.651	-4.47	8.63
	3.00	1.12	2.363	.885	-5.63	7.87
3.00	1.00	.96	2.198	.902	-5.32	7.24
	2.00	-1.12	2.363	.885	-7.87	5.63

Based on observed means.

The error term is Mean Square(Error) = 18.033.

FES-I as DV

Tests of Between-Subjects Effects

Dependent Variable: FOF_Total

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	55.643[a]	12	4.637	.386	.933
Intercept	4839.582	1	4839.582	402.600	.000
Age_Group	6.020	2	3.010	.250	.784
Types_Group	13.438	2	6.719	.559	.593
YogaYears_Group	8.841	2	4.421	.368	.703
Age_Group * Types_Group	2.513	1	2.513	.209	.660
Age_Group * YogaYears_Group	.000	0	.	.	.
Types_Group * YogaYears_Group	.000	0	.	.	.
Age_Group * Types_Group * YogaYears_Group	.000	0	.	.	.
Error	96.167	8	12.021		
Total	6777.000	21			
Corrected Total	151.810	20			

a. R Squared = .367 (Adjusted R Squared = -.584)

Multiple Comparisons

Dependent Variable: FOF_Total

Tukey HSD

(I) Age_Group	(J) Age_Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.7619	1.74726	.902	-5.7546	4.2308
	3.00	.5714	2.03013	.957	-5.2296	6.3724
2.00	1.00	.7619	1.74726	.902	-4.2308	5.7546
	3.00	1.3333	1.93386	.776	-4.1926	6.8592
3.00	1.00	-.5714	2.03013	.957	-6.3724	5.2296
	2.00	-1.3333	1.93386	.776	-6.8592	4.1926

Based on observed means.

The error term is Mean Square(Error) = 12.021.

FES-I as DV - Continued

Multiple Comparisons

Dependent Variable: FOF_Total

Tukey HSD

(I) Types_Group	(J) Types_Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1250	1.87245	.998	-5.4754	5.2254
	3.00	1.9464	1.79440	.549	-3.1810	7.0738
2.00	1.00	.1250	1.87245	.998	-5.2254	5.4754
	3.00	2.0714	1.92892	.555	-3.4404	7.5832
3.00	1.00	-1.9464	1.79440	.549	-7.0738	3.1810
	2.00	-2.0714	1.92892	.555	-7.5832	3.4404

Based on observed means.

The error term is Mean Square(Error) = 12.021.

Multiple Comparisons

Dependent Variable: FOF_Total

Tukey HSD

(I) YogaYears_Group	(J) YogaYears_Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.0000	2.25826	1.000	-6.4529	6.4529
	3.00	.7143	2.39253	.952	-6.1222	7.5508
2.00	1.00	.0000	2.25826	1.000	-6.4529	6.4529
	3.00	.7143	1.67632	.906	-4.0757	5.5043
3.00	1.00	-.7143	2.39253	.952	-7.5508	6.1222
	2.00	-.7143	1.67632	.906	-5.5043	4.0757

Based on observed means.

The error term is Mean Square(Error) = 12.021.

Indiana University Institutional Review Board Materials and Approval

Erica Nicole

User Name
Docherty, Carrie
Koceja, David

Protocol Aggregator

User Name
Mills, Erica Nicole
Stager, Joel M

Actions

Description	Comments	Action Date
Expedited Approval	Amendment-001: Approved	01/20/2016
Submitted to IRB	Amendment-001: Submitted to IRB	01/20/2016
Returned To PI	Amendment-001:	01/20/2016
Submitted to IRB	Amendment-001: Submitted to IRB	01/19/2016
Returned To PI	Amendment-001:	12/20/2015
Submitted to IRB	Amendment-001: Submitted to IRB	12/10/2015
Amendment Created	Amendment-001: Created	12/10/2015
Expedited Approval	Minimal Risk; Waiver of documentation of informed consent under 45 CFR46.117(c)	11/11/2015
Submitted to IRB	Submitted to IRB	11/11/2015
Returned To PI		11/11/2015
Submitted to IRB	Submitted to IRB	10/29/2015
Returned To PI		10/14/2015
Submitted to IRB	Submitted to IRB	10/06/2015
Protocol Created	Protocol created	10/05/2015

Questionnaires

Label
A - Level of Review Assessment
B - Lay Summary & Research Design
C - Sites & Collaborations
D - Recruitment Methods
E - Risks, Benefits, Protections
F - Data Safety Monitoring
H - Informed Consent Process
K - HIPAA
M - ClinicalTrials.gov
Conflicts of Interest

Attachments

Description	Attachment Type	Last Updated	Updated By
Protocol for each test administered.	Data Collection Instrument	10/06/2015 19:44:44	enmills
Control Participant Flyer	Recruitment Materials	10/06/2015 21:21:23	enmills
Yoga Practitioner Flyer	Recruitment Materials	10/06/2015 21:21:48	enmills

Attachments

Description	Attachment Type	Last Updated	Updated By
Amended study information sheet and survey to be sent to potential subjects prior to enrollment in the study.	Study Information Sheet	12/10/2015 11:07:04	enmills

Other Attachments

Description	Last Updated	Updated By
Written statement describing the research.	10/06/2015 19:30:21	enmills
Template for each subject's review of performance to be sent to them via email once their testing is complete.	10/06/2015 20:42:00	enmills

Determinations

Determination	Date Assigned	Date Inactive	Status	Comments
Minimal Risk	11/11/2015		A	IRB-IUB
Waiver of documentation of informed consent under 45 CFR46.117(c)	11/11/2015		A	IRB-IUB

IRB APPROVAL

This research project, including all noted attachments, has been reviewed and approved by the Indiana University IRB.

☐ Exempt Category(ies), if applicable:

☒ Expedited Category(ies), if applicable: (4)

Authorized IRB Signature: ______________________________ IRB Approval Date: ______________

Printed Name of IRB Member: ______________________________

KC IRB
Protocol #: 1510354087
Investigator: Stager, Joel M
Summary Printed 04/05/2016

Review Comments

Protocol Number:	1510354087		
Principal Investigator:	Stager, Joel M		
Title:	Balance and Fall Risk Assessment in Adult Habitual Yoga Practitioners		
Committee Id:	IRB00000222	**Committee Name:**	IRB-IUB
Schedule Id:		**Schedule Date:**	

Review Comments:

Balance and Fall Risk Assessment in Adult Habitual Yoga Practitioners

INDIANA UNIVERSITY STUDY INFORMATION SHEET
for Balance and Fall Risk Assessment in Habitual Adult Yoga Practitioners.

You are invited to participate in a research study of assessing balance measures for habitual yoga practitioners and healthy adults. You were selected as a possible subject because you may fall in either of these categories. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by Dr. Joel Stager and Erica Mills of the Department of Kinesiology.

Study Purpose:
The purpose of this study is to determine if habitual adult yoga practitioners differ from healthy controls in balance measures that are known to predict the risk of falling.

Number of Participants:
If you choose to participate, you will be one of 60 individuals who will be completing this survey and participating in a 45 minute balance evaluation.

Procedures for the Study:
If you agree to take part in the study, you will do the following things:
1. Survey and Informed Consent: Provide a brief personal background and consent to the study.

2. Contact: Should you qualify for the study, based on your survey responses, you will be contacted to come to the designated testing facility to complete the balance evaluation. The evaluation will take approximately 45 minutes to complete.

3. Activity Questionnaire: Complete the 5 minute history questionnaire and the global physical activity questionnaire (GPAQ).

4. Balance Evaluation: The researcher will guide and score you on the Balance Evaluation Systems Test (BESTest) that can be used to asses your risk of falling as well as the Balance Error Scoring System (BESS). The following categories will be scored: biomechanical constraints, stability limits/verticality, transitions/anticipatory, reactive, sensory orientation, and stability in gait. You should be tested with flat heeled shoes or with shoes and socks off. You should also be tested after avoiding balance altering substances for at least 24 hours. This includes, but is not limited to alcohol, balance altering medications, and caffeine. If you currently take prescribed balance altering medications, you will not be eligible to take part in this study.

Risks of Taking Part in the Study:
While taking part in the study, the risks are:
The risk of completing the survey is being uncomfortable answering the questions.
The risk of possible loss of confidentiality.

The risk of injury is about the same during daily activity, which could include unintentional falls.
While you are completing balance tests, a certified CPR, First-Aid, and yoga trainer will be present to prevent a fall.
Although you are encouraged to provide your best effort, you will not receive additional benefits based on your performance.

Benefits of Taking Part in the Study:
You will receive a summary of your performance on the BESTest and the BESS that may be indicative of your risk of falling and balance performance.

Confidentiality:
Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study my be published.
Organizations that inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP) who may need to access your medical and/or research records.

Compensation for Injury:
In the event of physical injury resulting from your participation in this research, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. Also, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled. If you are participating in research that is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

Payment:
You will not receive payment for taking part in this study.

Contacts for Questions or Problems:
For questions about the study, contact researcher Erica Mills at enmills@indiana.edu or 859-583-0847 or Dr. Joel Stager at 812-855-1637.
For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at 317-278-3458 [for Indianapolis] or 812-856-4242 [for Bloomington] or 800-696-2949.

Voluntary Nature of Study:
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University.

* 1. Please enter your name and email so that we can schedule a testing date should you qualify to take part in this study.

Name [ ]

Email Address [ ]

* 2. What is your gender?

◯ Female

◯ Male

* 3. What is your birth date? (mm/dd/yyyy)

[ ]

* 4. Are you currently suffering from an injury or are you currently in pain?

◯ Yes

◯ No

5. Please list any major health concerns. (Including, but not limited to, vertigo, spinal cord injury, multiple sclerosis, cerebral palsy, stroke, and ALS)

[ ]

* 6. Has your doctor ever said that you have a heart condition AND that you should only do physical activity recommended by a doctor?

◯ Yes

◯ No

* 7. Do you feel pain in your chest when you do physical activity?

◯ Yes

◯ No

* 8. In the past month, have you had chest pain when you were not doing physical activity?

- Yes
- No

* 9. Do you lose your balance because of dizziness or do you ever lose consciousness?

- Yes
- No

* 10. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

- Yes
- No

* 11. Is your doctor currently prescribing drugs for your blood pressure or heart condition?

- Yes
- No

* 12. Do you know of any other reason why you should not do physical activity?

- Yes
- No

* 13. For each of the following activities, please select the opinion closest to your own to show how concerned you are that you might fall if you did this activity. Please reply thinking about how you usually do the activity. If you currently don't do the activity (example: if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity.

	Not at all concerned	Somewhat concerned	Fairly concerned	Very concerned
Cleaning the house (e.g. sweep, vacuum, dust)	◯	◯	◯	◯
Getting dressed or undressed	◯	◯	◯	◯
Preparing simple meals	◯	◯	◯	◯
Taking a bath or shower	◯	◯	◯	◯
Going to the shop	◯	◯	◯	◯
Getting in or out of a chair	◯	◯	◯	◯
Going up or down stairs	◯	◯	◯	◯
Walking around in the neighborhood	◯	◯	◯	◯
Reaching for something above your head or on the ground	◯	◯	◯	◯
Going to answer the telephone before it stops ringing	◯	◯	◯	◯
Walking on a slippery surface (e.g. wet or icy)	◯	◯	◯	◯
Visiting a friend or relative	◯	◯	◯	◯
Walking in a place with crowds	◯	◯	◯	◯
Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)	◯	◯	◯	◯
Walking up or down a slope	◯	◯	◯	◯
Going out to a social event (e.g. religious service, family gathering, or club meeting)	◯	◯	◯	◯

* 14. In the past 12 months, how many times have you unintentionally fallen?

If you participate in the practice of yoga, please answer the following questions. If you do NOT practice yoga, please click next.

15. How long have you been practicing yoga regularly?

[ ]

16. In a typical week, how many days do you practice yoga?

1	2	3	4	5	6	7
○	○	○	○	○	○	○

17. How much time do you spend practicing yoga on a typical day?

[ ]

18. What type of yoga do you practice regularly? (Check all that apply)

- [ ] Hatha
- [ ] Vinyasa
- [ ] Iyengar
- [ ] Bikram
- [ ] Kundalini
- [ ] Ashtanga
- [ ] Other (please specify)

[ ]

19. Are you a yoga instructor?

- ○ Yes
- ○ No

The following question will help us set up a convenient time to do a simple, 45-minute balance test with you, should you qualify for our study.

20. In a typical week, when would you be available to complete the balance test? (Click all that apply)

	5 AM - 7 AM	7 AM - 9 AM	9 AM - 11 AM	11 AM - 1 PM	1 PM - 3 PM	3 PM - 5 PM	5 PM - 7 PM	7 PM - 9 PM
Monday	☐	☐	☐	☐	☐	☐	☐	☐
Tuesday	☐	☐	☐	☐	☐	☐	☐	☐
Wednesday	☐	☐	☐	☐	☐	☐	☐	☐
Thursday	☐	☐	☐	☐	☐	☐	☐	☐
Friday	☐	☐	☐	☐	☐	☐	☐	☐
Saturday	☐	☐	☐	☐	☐	☐	☐	☐
Sunday	☐	☐	☐	☐	☐	☐	☐	☐

Balance and fall risk assessment in habitual adult yoga practitioners.
Review of Performance

Dear *Insert Subject Name*,

I wanted to thank you once again for participating in our study on balance and fall risk assessment in habitual adult yoga practitioners. As you may remember, the benefit of participating in the study was to receive feedback on your personal balance measurements taken while in the laboratory. Please consult a doctor if you have concerns about these results, as we are unable to provide you with medical advice.

Your Balance Evaluation-Systems Test Results:

Section I, Biomechanical Constraints: ____/15

Section II, Stability Limits/Verticality: ____/21

Section III, Transitions/Anticipatory: ____/18

Section IV, Reactive: ____/18

Section V, Sensory Orientation: ____/15

Section VI, Stability in Gait: ____/21

Total: ____/108

Percent Total Score: ____%

69% is the cut off score to identify an individual as a faller or a non-faller.[2]

Your Balance Error Scoring System Results:

The number of errors are listed under each condition. The maximum number of errors under each condition is 10.

	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot in back)		
Total Scores		

According to normative data, the average number of errors for individuals between the ages of 55 and 59 is 16.5. For individuals 60-64 years old, the average errors are 18.0.[1]

Please respond to this email with any questions you may have about the study.

Balance and fall risk assessment in habitual adult yoga practitioners.
Review of Performance

Thank you,

Erica Mills

Exercise Physiology Masters Student
Indiana University School of Public Health

1. Iverson, G. L., & Koehle, M. S. (2013). Normative data for the balance error scoring system in adults. *Rehabilitation research and practice, 2013*.

2. Leddy, A. L., Crowner, B. E., et al. (2011). Functional gate assessment and balance evaluation system test: reliability, validity, sensitivity, and specificity for identifying individuals with Parkinson disease who fall. *Physical Therapy* 91(1): 102-113.

CONTROL SUBJECTS NEEDED

A Study on the Benefits of Yoga on Aging and Balance

Study includes assessments of:

- Fear of falling
- Daily activity
- Balance

Contact us if:

- You are between 55-65 years old
- You are not currently practicing yoga

School of Public Health

IRB #1510354087

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YOGA PRACTITIONERS NEEDED

A Study on the Benefits of Yoga on Aging and Balance

Study includes assessments of:

- Fear of falling
- Daily activity
- Balance

Contact us if:

- You are between 55-65 years old
- Practice yoga at least 3 times per week
- Have been practicing yoga at least 8 weeks

School of Public Health

IRB #1510354087

Yoga Practitioner
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Protocol 1510354087 IRB Approved