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THE EFFECTS OF VINYASA YOGA PRACTICE ON FITNESS LEVELS OF HEALTHY ADULTS

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by

Christine LaMonica Inniss

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The thesis of Christine LaMonica Inniss is approved:

Shane Stecyk, Ph.D. Date

Konstantinos Vrongistinos, Ph.D. Date

Jennifer L. Romack, Ph.D., Chair Date

California State University, Northridge

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ABSTRACT

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The number of adults practicing yoga for fitness benefits grows every year, but there is little empirical evidence to support the presumption that yoga improves their physical fitness levels. The purpose of the present study was to establish whether practicing a vigorous style of yoga (Vinyasa) three times per week for eight weeks improved fitness levels of adult yoga novices. Thirty-one healthy participants (M = 24.2 years, SD = 6.1 years) were randomly placed into one of two groups, a yoga training (n = 15) or a control (n = 16) group. Levels of dynamic balance, power and core muscular strength/endurance were measured for each participant at the beginning (Time 1) and end (Time 2) of an eight-week period. To assess dynamic balance participants performed a star excursion test. They then completed a maximum vertical jump to assess power. Finally, participants performed three tests (flexor, extensor, side bridge) to assess core musculature strength/endurance. After baseline testing, the yoga training group participated in two 80-minute yoga classes and one 50-minute yoga home practice per week for eight weeks, while the control group abstained from any yoga practice. At the end of the eight-week training period both the yoga training group and the control group were tested again using the same testing protocol as the Time 1 testing. A mixed multivariate analysis of variance (MANOVA) was conducted to test the effects of Vinyasa yoga training. Results showed that Vinyasa yoga training had a significant interaction (Group x Time) effect for a linear combination of five dependent variables (multivariate $F\ (5, 25) = 4.60$, $p < .01$, $\eta^2 = .48$). Subsequent separate univariate ANOVA tests for each dependent variable revealed significant interaction effects for dynamic balance (star excursion; $p < .01$), anterior muscular strength/endurance (flexor test; $p < .01$) and lateral muscular strength/endurance (side bridge test; $p < .05$). Follow-up group comparisons at Time 1 and 2 for each of the three dependent variables showed that only anterior core muscular strength/endurance ($p < .01$) improved for the Yoga Training group compared to the Control. Results from this study demonstrated that Vinyasa yoga training is an effective way for healthy adults to increase anterior core muscular strength/endurance. There were no training effects for posterior and lateral core muscular strength/endurance and dynamic balance. As predicted, there was also no effect for power.

Introduction

Yoga is a type of physical activity that involves mental, spiritual and physical practice. The practice of yoga was first organized and systematized by Patanjali around the 6th century BC in the classic treatise, *The Yoga Sutras* (Iyengar, 1966). *Yoga Sutras* detail the practice of yoga as an eight-limbed path, with one limb being the physical practice of poses (*asanas*) so the body is more comfortable during meditation practice in a sitting pose. The physical practice of poses as a means to enhance health and physical fitness is what attracts many adults to begin yoga.

Depending on the type of yoga practiced, *asanas* can range from mild to moderate to vigorous intensity. The mild versions use more seated poses with less physical effort, often incorporating props for support. The more vigorous styles, such as Vinyasa, use more standing poses and move through a sequence of poses. A Vinyasa yoga session starts with sun salute, which is a sequence of eighteen poses (Appendix A - see Figure 1). Then poses that follow the sun salute are those planned by the instructor. Poses and their sequence, therefore, can vary within and across Vinyasa practice sessions. Variation of poses enhances the adaptability of classes for different physical levels of yoga students. Some yoga instructors also believe that pose variation prevents boredom.

This study focused on Vinyasa yoga because planned poses and the sequence of these poses provide a better sense of what physical effects to expect then if yoga were practiced more idiosyncratic. For example, presumably, poses like chatturanga (see Appendix A - Figure 1. Pose 4) builds transverse abdominus and anterior and posterior deltoid strength/endurance, while virabhadrasana III (Appendix A - see Figure 2) builds the strength/endurance of core muscles, e.g. rectus abdominus and transverse abdominus, as well as muscles important to balance, e.g. the adductors and gluteus medius. In addition, Vinyasa-based yoga classes, sometimes called power yoga, are particularly popular in health clubs, fitness centers, and yoga studios as a way to improve other aspects of physical fitness.

Proponents of yoga have made claims about its effects on physical fitness. For example, *24 Hour Fitness*, one of the largest health club chains in the U.S., advertises that yoga “offers … benefits, such as improving balance and flexibility … and strengthening your core muscles” (“Mind/Body Classes,” n.d., para. 8). Another popular U.S. health club, *Equinox*, is known for group fitness classes, including yoga. Similar to *24 Hour Fitness*, *Equinox* advertises that “yoga practice will … improve your balance and flexibility and leave you stronger…” (“Yoga,” n.d., para.2). Some *Equinox* branches offer up to 22 yoga classes per week. Yoga practitioners also claim that yoga enhances the flexibility, strength, and balance aspects of fitness (Hollingshead, 2002; Macklin, 2010; Millado, 2010), and should therefore be added to a training regime (Macklin, 2010; Sherman, 2002).

Little rigorous empirical evidence directly supports such claims regarding the effects of yoga muscular strength/endurance and balance of healthy adults. A small set of studies showed that yoga practice increased muscular strength in the trunk, upper arms, hamstrings, upper body, or hands (Cowen & Adams, 2005; Madanmohan et al., 1992; Tran, Holly, Lashbrook, & Amsterdam, 2001) of adults but these studies were limited by either sample size or lacked a control group. Little, if any, research has directly examined the impact the yoga has specifically on core muscle groups in healthy adults. However, some low back pain studies have addressed yoga and core strength indirectly

(Sherman, Cherkin, Erro, Miglioretti, & Deyo, 2005; Tilbrook et al., 2011; Williams et al., 2005). Similarly, there is little empirical evidence to support presumptions related to yoga's effects on balance in healthy adults. Hart and Tracy (2008) found balance improvements using a static balance test on healthy young adults. A group of studies examined adolescent, older adult, or injured populations (Oken et al., 2006; Tilbrook et al., 2011; Williams et al., 2005) with differing results. Many of the balance studies used a static balance test although much of yoga involves controlling dynamic balance while transferring from one pose to another. A separate study examined less vigorous styles of yoga (Hatha) and showed no improvement in cardiovascular fitness (Clay, Lloyd, Walker, Sharp & Pankey, 2005). Finally, another set of studies consistently showed a variety of yoga styles helps flexibility (Boyle, Sayers, Jensen, Headley, & Manos 2004; Cowen & Adams, 2005; Donahoe-Fillmore, Brahler, Fisher, & Beasley, 2010; Tran et al., 2001).

The primary purpose of this study was to examine the effects of a vigorous style of yoga training (Vinyasa) on physical fitness, specifically core muscular strength/endurance and dynamic balance of healthy adults. It was hypothesized that eight weeks of training (3 times per week) would increase core muscular strength/endurance and improve dynamic balance. According to Baechle and Earle (2008), this resistance training dose was sufficient for muscle fiber hypertrophy and strength gains, with resistance in yoga being an individual's body weight. A secondary purpose was to examine if the vigorous nature of Vinyasa yoga practiced at the prescribed training dose would also affect levels of power. It was hypothesized that there would be no effect on power. Although Vinyasa is a vigorous style of yoga, it requires one to control strength within and between poses as opposed to using strength explosively. This study will inform those interested in adding yoga, either as a supplement to their current exercise regime or as a stand-alone method, for the physical benefits on Vinyasa yoga practice.

Methods

Experimental Approach to the Problem

This study was designed to test the hypotheses that eight weeks of Vinyasa yoga practice three times per week would have a positive effect on core muscular strength/endurance and dynamic balance, and no effect on power among healthy adults. A two-way mixed design (Group x Time) was used to test both hypotheses. Group (Yoga Trained, Control) served as the between factor whereas Time (1, 2) served as the repeated factor. Muscular strength/endurance, dynamic balance, and power were assessed for each participant prior to (Time 1 – week 0) and after (Time 2 – week 9) an eight-week period (week 1 – 8).

Subjects

Forty-three healthy adults were initially recruited via flyers posted at a large public urban university campus in California. Participation criteria included : (a) no more than six months of yoga experience (i.e. beginners), (b) not pregnant, (c) at least 18 years of age, and (d) free of health conditions. Interested participants contacted the researcher, and then were subsequently asked to attend one of two informational sessions held on different days and times to accommodate various schedules. Participants who attended the first information session were, as a group, randomly assigned (via a lottery draw) to the Yoga Training group, whereas participants attending the second information session were the Control group. Each information session started with a description of the study. Then, those attendees who were interested completed an informed consent form, a basic health questionnaire, and baseline testing (Time 1 – week 0). At week 0, the Yoga

Training and Control groups consisted of 22 and 21 volunteers, respectively. One week after testing, the Yoga Training group began practicing (week 1). At the end of eight weeks (week 8), both the Yoga Training and Control groups were tested again (Time 2 - week 9). Following testing, each participant in the Control group received a voucher for a total of seven free yoga sessions at two nearby yoga studios. The study was approved by the university's Standing Advisory Committee for the Protection of Human Subjects.

Procedures

For Time 1 and 2 testing sessions, participants wore comfortable physical activity attire and shoes. Testing was conducted in a biomechanics laboratory on the university campus. Participant characteristics, such as age (years), height (inches), and weight (pounds were measured and recorded at Time 1. Participants then completed a total of five fitness tests (see Appendix A - Figures 3-7): star excursion (dynamic balance), maximum vertical jump (power), flexor test (anterior muscular strength/endurance), side bridge test (lateral muscular strength/endurance), and a modified Biering-Sorensen test (extensor test of posterior muscular strength/endurance). Tests widely used among strength and conditioning professionals and feasible for yoga practitioners to apply in the field were selected (DiMattia, Livengood, Uhl, Mattacola & Malone, 2005; Harman, Rosenstein, Frykman & Sosenstein, 1990; Leetun, Ireland, Willson, Ballantyne, & Davis, 2004; McGill, Childs, & Liebenson, 1999; Munro & Herrington, 2010). Tests used to assess muscular strength/endurance were performed to the point of failure therefore these tests were conducted last. Participants could practice each of the tests once if they chose, and between each test they rested up to five minutes. Testing took approximately 30 minutes per subject. Participants also completed the Baecke Questionnaire of Habitual Physical Activity at Time 1 and Time 2.

Assessment of dynamic balance. The star excursion balance test is a test of dynamic balance (see Appendix A - Figure 3) with an intraclass correlation (*ICC*) score of 0.84-0.92 (Munro & Herrington, 2010). The star test is lower extremity reaching task that is more complex and integrated than a static one-legged or tandem balance test. Participants stood on their preferred support leg with the most distal part of their big toe on the center-line of the grid and the heel at the center. While keeping the heel of the support heel on the floor, participants reached as far as possible in three different directions (anterior, posterolateral and posteromedial) with the lifted leg while maintaining balance on the support leg. Weight remained over the standing leg so the reaching leg would just tap the testing mat. If any weight-bearing occurred on the reaching leg, the participant was instructed to repeat the reach. Up to five practice trials were performed before one testing trial was scored. Their score was based upon which pre-scored line (ranging from 30-90 points) they reached on the grid with the reaching leg. One score for each direction was recorded. Preferred leg (right or left) was also recorded at Time 1 for accurate reproduction at Time 2.

Assessment of power. The counter movement vertical jump (CMVJ) is a test of power (Harman et al., 1990) with an *ICC* measure of 0.98 (Markovic, Dizdar, Jukic & Cardinale, 2004). The participant stood on a taped line one foot from the front of the base of a Vertec machine (Appendix A - see Figure 4). Standing on both feet, each participant reached as high as possible with the preferred arm to adjust the Vertec for reach height. Then, using a counter arm movement, the participant jumped and touched the highest marker on the Vertec (jump height). The difference between jump height and reach height was their score for the CMVJ. Participants were given one practice jump followed by a single test jump. The test jump was measured and recorded in inches.

Assessment of muscular strength/endurance. Anterior core strength/endurance was tested using the flexor test as described by McGill et al. (1999) with an *ICC* reliability measure of 0.93. The participant sat on the testing surface with the back resting against a support at a 60 degree angle with the knees bent and the feet flat on the testing surface so that the knees and hips are flexed to 90 degrees (see Appendix A - Figure 5). The arms were folded across the chest with the hands on opposite shoulders and the toes fixed to the testing surface with a strap. Participants maintained a flat back with no rounding of the shoulders as the support was removed from behind them and the timing began. This position was maintained as long as possible (i.e. to failure). The timing stopped when their body position fell below 60 degrees. The total time maintained in the proper position was recorded in seconds.

Posterior core strength/endurance (i.e. extensor) was tested using the modified Biering-Sorensen test (Leetun et al., 2004) with an *ICC* reliability measure of 0.99 (see Appendix A - Figure 6). Participants laid prone on the testing surface with their lower body fixed to the surface with straps at the ankles, knees and just below the buttocks, with the upper body (beginning at the top of the hip) extended over the edge of the test surface. The participants supported their body weight with their arms on a chair directly under their torso until they were ready to begin the test. They positioned themselves so their torso was in line with their lower body and were instructed to maintain this straight line of upper and lower body as long as possible, without using their hands, until failure.

Timing started when hands lifted off the chair and arms crossed over the chest. The elevated position was timed until the upper body lowered below parallel or hands returned onto the chair. The time the participant remained parallel was recorded in seconds.

Lateral core strength/endurance was tested using the side bridge test with an *ICC* of 0.96 (McGill et al., 1999). Participants laid on their side with legs extended and the top foot in front of the bottom foot on the testing surface, for balance. The bottom elbow was flexed, directly under the shoulder, with the forearm and hand on the testing surface. Participants supported themselves by raising the bottom hip and thigh away from the testing surface and creating a straight line with the body, from feet to head (see Appendix A - Figure 7). Timing began when their body lifted away from the testing surface and stopped when they could no longer maintain the lifted position contact resumed. Total time (in seconds) the body was lifted was recorded.

Yoga training protocol. The yoga training period (weeks 1-8) consisted of two 80-minute asana practices on campus plus a 50 minute at home practice via DVD each week. The Control group abstained from any yoga practice. There are many different styles of yoga, ranging from very mild to very vigorous physical practice. The yoga utilized in this study was a Vinyasa style of yoga based in the Iyengar and ashtanga traditions as taught by B.K.S. Iyengar and Sri K. Pattabhi Jois, respectively. The classes incorporated a wide variety of vigorous yoga poses including the warrior poses, navasana, bakasana and inversions, such as handstand. Participant attendance was recorded for the on campus practice sessions. In addition, at the start of each week participants recorded in a logbook whether or not they completed the home practice over the previous week-end, perceived effort during home practice, and other comments.

Statistical Analyses

A mixed multivariate analysis of variance (MANOVA) was conducted to test the effect of Vinyasa yoga training on aspects of physical fitness. One between (Group) and one repeated factor (Time) was used to evaluate whether there was an effect of yoga on the fitness variables (dynamic balance, strength/endurance, and power) as a group. Each factor included two levels. The dependent measures were scores on the following fitness tests: star excursion, counter movement vertical jump, flexor test, extensor test, and side bridge test. For significant multivariate *F* results, separate univariate *F* tests were used to analyze each dependent variable. Significant univariate Fs for dependent variables were followed by independent sample t-tests to determine differences between groups at Time 1 and Time 2. Significance was set at an alpha level of less than .05. Statistical procedures were performed using IBM SPSS Standard Statistics Version 20.

Results

The initial recruited sample of the Yoga Training group became smaller within the first weeks of the training due to attrition. By the end of week 3, five yoga participants stopped coming and did not respond to a follow-up email sent by the researcher. However, the remaining number of participants in the Yoga Training group (n = 17) was consistent from week 3 until the start of week 8 (see Appendix A - Table 1). At week 8, two more participants stopped training because of injuries unrelated to yoga. The final sample size at Time 2 for the Yoga Training group was 15. For the Control group, five participants did not complete Time 2 testing, leaving a final sample size of 16. Descriptive statistics of participant characteristics of both groups are presented in Table 2. A single factor Anova test performed for each descriptive characteristic at Time 1 revealed no differences between the two groups on either age (p = .10), height (p =.53) or weight (p = .57).

A mixed MANOVA was used to create an optimal linear combination of dependent variables that predicts the variance associated with the two independent variables (Group, Time). Bivariate correlations were first performed on the seven dependent measures to avoid multi-collinearity during the MANOVA. Because the three directions of the star excursion test (forward, right and left) were highly correlated (r = .73 to .77), a combination score of the three directions was used to avoid multicollinearity. The subsequent mixed MANOVA was used to examine which of five tests (combined star excursion, CMVJ, flexor test, extensor test, and side bridge test) contributed significantly to the separate levels of group over time.

Results of the MANOVA indicated a significant Group x Time interaction (F (5,

25) = 4.6, $p < .01$, partial $\eta^2 = .48$), therefore, the difference between the Yoga Training and Control groups on the linear combination of the five dependent variables was different at Time 1 and Time 2. Group means and the standard deviations of the five tests at Time 1 and Time 2 are depicted in Table 3. Separate subsequent ANOVA tests for the effects of Group on each dependent variable revealed a significant interaction effect for 3 of the 5 dependent variables (see Appendix A – Figures 8 - 12): combination star excursion ($F(1,29) = 10.9$, $p < .01$, $\eta^2 = .27$), flexor test ($F(1,29) = 15.9$, $p < .01$, $\eta^2 = .35$), and side bridge test ($F(1,29) = 5.3$, $p < .05$, $\eta^2 = .15$) tests.

Separate independent t-tests compared groups at Time 1 and Time 2 for the combination star excursion, flexor test, and side bridge test. For Time 1 comparisons, significant differences were found between groups for the combination star excursion (t (1, 29) = -2.342, $p < .05$). Because the groups differed for this dependent variable at Time 1 of the study, no further analyses were performed on this variable. Time 2 comparisons revealed significant group differences for the flexor test but not for the side bridge test. The Yoga Training group had significant improvements over the Control group only on the flexor test (t (1, 29) = 4.8, $p < .01$).

Discussion

Millions of people are turning toward yoga every year hoping to gain some of the purported physical benefits yoga practice can provide (Rosin, 2006). Athletes look to it for performance enhancement and injury prevention (Rosen, 2002). The general public sees yoga as a novel activity to gain physical benefits. Little rigorous research that has investigated the effects of Vinyasa yoga on fitness levels in healthy adults is evident in the literature. Purpose of this study was to examine the effects of eight weeks of a Vinyasa yoga practice (three times a week) on aspects of physical fitness among healthy adults. It was hypothesized that the vigorous yoga training used in this study would improve core muscular strength/endurance and dynamic balance. In addition, it was predicted that there would be no effect on power. The results of this study provides supporting evidence to claims that yoga improves some aspects of fitness, specifically if the yoga training is one that is more vigorous. Significant improvements were found in the muscular strength/endurance of the anterior muscle groups. Significant effects from yoga training were not found for dynamic balance as well as strength and endurance of the posterior and lateral muscle groups of the core. As predicted, no effects were observed in the explosive power component as measured by the countermovement vertical jump.

These findings are positive for in addition to enhancing fitness, low back pain (LBP) is another popular reason people begin yoga practice (Sherman et al., 2005). LBP is third only to knee and ankle injuries in keeping athletes off the field (Gamble, 2007), affects 80% of the adult population (Bernard, 2006) and up to 57% of adolescents (Harringe, Nordgren, Arvidsson, & Werner, 2007). While LBP can often resolve itself without medical intervention, it has a recurrence rate of up to 90% and often for unidentifiable reasons (Kolber & Beekhuizen, 2007). Studies have examined the effectiveness of yoga as a treatment for LBP and have found much success (Sherman et al., 2005; Williams et al., 2005) but reasons as to why yoga was successful have not been clear. One study showed that a lack of strength and endurance of the core musculature can be a leading cause of LBP (Leetun et al., 2004). A deficit in core muscular strength and endurance can lead to disturbances throughout the kinetic chain making the lower back more susceptible to injury (Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007a). It's possible that yoga helps improve LBP as a result of increasing the muscular strength and endurance of core. Further research into this area is warranted.

In addition to treatment and prevention of LBP, the anterior core muscular strength/endurance gains seen in the present study may also be an important part of lower extremity injury prevention (Leetun et al., 2004), specifically to the anterior cruciate ligament (ACL) of the knee. Considering that ACL injuries have an annual health care cost of up to $2.5 billion annually and there are approximately 95,000 new injuries each year (Padua & Marshall, 2006), ACL injury prevention is of great importance. A study by Zazulak et al. (2007a) found that deficits in core stability (i.e. the ability to control the trunk in the face of perturbation) were a strong indicator of people at risk for knee injury. A lack of core strength/endurance is an important contributing factor to core instability (Zazulak et al., 2007a). The current study showed statistically significant increases in flexor core muscular strength/endurance, which indicates that yoga could be a useful tool in the approach to knee injury prevention via core stability.

While several studies have attempted to correlate core strength/endurance to performance, there has been little success (Hibbs, Thompson, French, Wrigley & Spears, 2008; Nesser & Lee, 2009; Nikolenko et al., 2011) and this seems to hold true here as well. The Vinyasa yoga practiced during the course of this study had excellent results with respect to anterior core muscular strength/endurance increases, but had no effect on power, a performance-related fitness component. Power, as measured via the CMVJ, requires a short, quick burst of energy and that is not typical of what is required in yoga, and specifically not what was required of the Yoga Training group in this study. Rather, Vinyasa participants were required to hold poses, sustaining a specific position for several breaths. Even when jumping was required, it was always with control and never done to maximum effort or velocity. It is not surprising that significant improvements in this test did not occur. If there is a link between core muscular strength/endurance and performance, it is indirect. Certainly having fewer injuries and therefore being able to practice more, injury free, would be an assumed boon to performance.

It was unfortunate that group differences in the combination star excursion test existed at Time 1 of this study. The purpose of using this test was to assess dynamic balance. Dynamic balance has been shown to help prevent injuries to the knees and ankles. Dynamic balance becomes more and more relevant with age as balance begins to decrease. Balance has some correlations to performance in a wide variety of sports from rifle shooting to gymnastics to soccer and often the more elite athlete will have better balance than the less proficient one (Hrysomallis, 2011). But perhaps more important is the role balance plays in injury prevention. Like core muscular strength/endurance, balance has long been known as an important part of injury prevention in the lower extremities and the low back (Hrysomallis, 2007; Leetun et al., 2004). In a review of studies examining ACL injury prevention programs, Bien (2011) found that balance training can be an effective part of ACL injury prevention. Balance is especially important for people as they age, as falling increases as we get older and so does the rate of injury with those falls (Howe et al., 2011).

Practical Applications

The results of this study show that Vinyasa yoga is an effective tool that can be added to an established fitness routine or adopted as a stand-alone practice for anyone interested in improving their core muscular strength/endurance. Core muscular strength/endurance is important in maintaining the health of the spine as well as preventing injuries to the lower back and the lower extremities. Yoga has become popular with people at all levels of fitness, from elite athletes to those with little exercise experience. While there may be different motivations to attend yoga class, the assumptions that a Vinyasa yoga practice will improve anterior core muscular strength/endurance was supported in this study.

Review of Literature

Many yoga practitioners and health and fitness magazines cite anecdotal evidence for the fitness benefits to practicing yoga. Health clubs across the country offer yoga classes as part of their group fitness schedules, promoting these classes as ways to increase fitness. *24 Hour Fitness*, one of the United States largest health club chains, promotes yoga on their website: "Along with putting you in touch with your Zen, yoga also offers loads of other benefits, such as improving balance and flexibility, promoting circulation and strengthening your core muscles" ("Mind/Body Classes," n.d., para. 8), yet the scientific research to back up these claims is nearly non-existent. Another U.S. health club chain, *Equinox*, known for its group fitness classes, promotes yoga in a similar way: "A committed yoga practice will enhance your stability, improve your balance and flexibility and leave you stronger, healthier, more energized and centered for your day." ("Yoga," n.d., para.2). A local branch offers 22 yoga classes weekly. By the end of 2010, 20.2 million Americans had practiced yoga at least once, up 28% from the previous year (NSGA, 2012).

Many people seek out yoga for its perceived physical fitness benefits on health outcomes, such as improved flexibility, muscular strength and muscular endurance. Others seek out yoga for injury prevention and rehabilitation, especially for low back pain (Hollingshead, 2002; Macklin, 2010). And finally, others turn to yoga for its potential enhancement of performance-related outcomes such as better balance and motor control. This thesis section reviews empirical studies that focused primarily on the effects that yoga training has on physical fitness, specifically components categorized as either health- or performance-related fitness components.

Health-Related Fitness Components

According to the American College of Sports Medicine there are five components to health-related physical fitness: body composition, cardiorespiratory, flexibility, muscular strength, and muscular endurance. Body composition is the ratio of fat to fat-free tissue in the body. Cardiorespiratory fitness is indicative of how well the heart, lungs and muscles respond in relation to the specific demands of the activity being performed. Flexibility is the degree to which a joint can move through a range of motion without muscular pain. Muscular strength and muscular endurance are both related to strength, lean tissue mass and bone density but there is a difference between the two. Strength is the maximum force that a muscle or muscle group can generate at a specific velocity (Baechle & Earle, 2008), while endurance is being able to maintain continuous muscular tension, repetitive dynamic contraction or prolonged intense contractions. The current study examined the effects of a yoga training on two health-related fitness components: muscular strength and muscular endurance of the core musculature.

Muscular strength and endurance of core muscle groups. Core strength is an important aspect of health and fitness. It is essential in preventing low back pain and injury as well as preventing injuries to the knees and ankles (Ortiz, Olson, & Libby, 2006). The present study examined not just anterior core strength and endurance but also posterior and lateral because no one single core muscle dominates stability (and hence injury prevention), and even the roles of the individual muscles change with the task being performed (Standaert & Herring, 2007). The majority of past research supports a comprehensive approach, meaning that all the muscles of the core need to be trained in order to fully realize the benefits of core strength and stability training. Additionally, core strength is an essential part of balance, which also helps to prevent injury as well as enhance performance.

There is substantial evidence that improving core strength and stability can be an important factor in preventing lower extremity injury (Leetun, Ireland, Willson, Ballantyne, & Davis, 2004). This is highly relevant especially to athletes since the top three injury sites for athletes are lower extremities: lower back, knee and ankle (Gamble, 2007). The vast majority of the research addressed the importance of core strength and stability relative to two main areas of injury: low back and the knee (often specifically the anterior cruciate ligament (ACL). This is largely because so many studies related imbalances and/or weaknesses of the core to lower back pain and knee injuries (Ortiz et al., 2006). For example, a large set of studies pertained to core strength and endurance training and risk of ACL injury.

Many studies examined the effects of core strength and endurance training on ACL injury risk in athletes, as ACL injury is generally associated with sports, but the implications of these studies are applicable to athletes and non-athletes alike. The common factor among all the research articles was the statement that female athletes are at a greater risk of ACL injury than their male counterparts. A study by Leetun et al. (2004) showed that female athletes experience injuries such as ACL tears and various overuse injuries at a disproportionately higher rate than males. Zazulak, Hewett, Reeves, Goldberg, and Cholewicki (2007a) agreed that especially in sports that involve jumping or pivoting, the rate of female injury is greater than males. They went on to find that while impaired core proprioception was a predicting factor among female athletes, it wasn’t in males.

Zazulak et al. (2007a) looked at 277 collegiate athletes over a three-year period and tracked their injury rates. The study was fairly evenly divided with 140 females and 137 males. Participants were tested for core proprioception at the beginning of the study and the authors used regression analysis to determine if core deficits were responsible for the injury. No interventions were done; the athletes were simply tracked for injury rates. In this case, deficits in "active proprioceptive repositioning" (Zazulak et al., 2007a) predicted the knee injury rate in females only, with 90% sensitivity, which substantiated results presented by Ortiz et al. (2006) in a review article. The implication is that there appears to be a strong relationship between lower extremity injury and weakness in the muscles of the core.

Ortiz et al. (2006) reviewed three studies that focused on the relationship between core weakness and lower extremity injury. All three studies concluded that a relationship does exist. However while those studies found no relationship between hip abduction strength and injury risk, Leetun et al. (2004) found that the athletes who remained uninjured throughout their study had significantly more hip abduction strength than those who did not. Even so, they also found that external rotation strength was the only real predictor of whether an athlete would sustain an injury, but unlike Zazulak et al. (2007a), did not find a difference between sexes.

Similarly, Leetun et al. (2004) looked at 80 female and 60 male basketball and track athletes before the start of their seasons and tested their core strength using a hand-held dynamometer, the modified Biering-Sorensen test and side bridge test. As in the Zazulak et al. (2007a) study, this was observational and they followed the athletes through the course of one athletic season and tracked the injury rates. In addition to the findings regarding hip external rotation strength, the researchers noted that males generally had higher core stability measures than females, which could be a reason for females increased injury risk.

Myer, Ford, Palumbo, and Hewett (2005) looked at the effect of a 6-week neuromuscular training that included core strength and balance training as well as resistance training and interval speed training. The authors hypothesized that they would see significant improvement in the athletes' performance but also in the biomechanics that will help to prevent injury. At the end of the six weeks the researchers found significant improvements in both areas. The balance and core training was thought to improve postural control, knee valgus and varus which are all contributors to ACL injury risk (Myer et al., 2005). This supported the belief that a comprehensive training program can improve performance as well as injury preventive biomechanics (Myer et al., 2005).

A deficit in core strength and stability can lead to disturbances throughout the kinetic chain making the athlete more susceptible to injury (Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007b). In a study conducted by Zazulak et al. (2007b), the authors described how abdominal muscle fatigue can contribute to hamstring injury because of a delay in the activation of the muscle. The study hypothesized that core proprioception deficits would be a predictor of knee injury risk in female athletes. They theorized that because neuromuscular control is based on feedback from sensory information, if the system is not functioning properly then control would suffer. Consequently, the same can be said for poor core proprioception. If it is poor then control of the core will suffer which will lead to decreased control of the knee and could lead to knee injury. They found this to be the case but only for female athletes. These findings were similar to those of Nadler et al. (2002), which found a correlation of hip strength with incidence of lower back pain but only in females.

The gender issue is present here in the discussion of low back pain as well, as there is similar evidence linking core (specifically gluteus maximus) weakness to the incidence of low back pain (Nadler et al., 2002). Nadler et al. (2002) studied groups of NCAA athletes over two consecutive seasons. They were evaluated for hip extensor and abductor strength after routine physical examinations. After the evaluations, the athletes were tracked by athletic trainers during the following year for any injury requiring treatment for low back pain. The authors observed two groups of athletes over two years. During the second year of the study a 30-45 minute core strengthening routine was implemented into their regular training regimens. This study found no significant correlation between the incidence of low back pain in males and the core-strengthening program they implemented. The incidence in females actually rose, but the small participants sample size with low back pain limited inferences. The authors recommended the need for more research in this area because of the observed trend of right hip extensor weakness among those female athletes who did develop low back pain during the course of the study.

A similar core strengthening approach was taken in a study of 42 female gymnasts, about half of whom were suffering from low back pain. Harringe, Nordgren, Arvidsson, and Werner (2007) divided their participants into two groups. The intervention group was given isometric exercises that were meant to strengthen the transverse abdominus and the lumbar multifidus muscles specifically. They found significantly less reports of low back pain in the intervention group than the control and many of the low back pain participants in the intervention group actually became pain free. While this study could not control for all the training that was done outside the study, all the participants competed in the same sport and the results are encouraging that a core-strengthening program could be beneficial in the prevention and resolution of low back pain.

While Harringe et al. (2007) found significant results training specifically the transverse abdominus and the lumbar multifidus, in 2004 a study by Kavcic, Grenier, and McGill showed that there was no single core muscle that played a dominant role in stabilizing the spine and that all the muscles of the core are equally important with their roles changing across different activities. Their study recommended focusing on motor patterns rather than on specific muscles. Furthermore, Standaert and Herring (2007) stressed that it could potentially be detrimental to focus on specific muscles over the functioning of the group as a whole.

Kofotolis and Kellis (2006) did a study with 80 women all with chronic low back pain. These participants were not athletes and instead of being given a more traditional strength-training regimen they were divided into three groups. Two were given different types of PNF (proprioceptive neuromuscular facilitation) exercises and the third group served as a control. PNF exercises are different in that their main goal is to simulate what the muscle might actually being doing during a sport by enhancing the neuromuscular response via proprioceptor facilitation rather than simply trying to strengthen the muscles. Intervention participants were split into two PNF groups, one being taught rhythmic stabilization training and the other combination of isotonic exercises. Of particular interest to the researchers was increased trunk stabilization and decreased back pain at the end of the four-week study period. What were found were increases in flexibility, range of motion and endurance in the lumbar spine, but in regard to the pain in the lower back, the levels stayed relatively the same. This led to the conclusion that improvements in flexibility and range of motion do not necessarily lead to pain reduction. However, increases in flexibility and range of motion of the spine are encouraging and indicate that further study is needed, possibly allowing more time for the intervention phase of the study.

The general consensus of these past studies is that core stability and strength training can be an important part of a program designed to prevent lower extremity injury. There have been multiple approaches taken to achieve that end with varying results, but it is important to bring balance and stability to the lumbar spine and its surrounding muscles regardless of the approach. Certainly the evidence indicates there are preventative benefits available with a comprehensive approach to training the spinal stabilizers and core musculature (Kolber & Beekhuizen, 2007).

Effects of Yoga on Core Musculature Strength and Endurance. The question now is whether yoga is an appropriate tool to facilitate strengthening the musculature of the core. While there is copious empirical evidence that yoga increases flexibility (Boyle, Sayers, Jensen, Headley, & Manos, 2004; Cowen & Adams, 2005; Donahoe-Fillmore, Brahler, Fisher, & Beasley, 2010), research elucidating the core muscular strength and endurance benefits is scarce. Some evidence has indicated that yoga is effective at increasing trunk and upper body strength (Silver, 2005; Tran, Holly, Lashbrook, & Amsterdam, 2001). But the limitations to these studies are their small size (N = 3–10) and/or no control group. One research study compared the benefits of a hatha yoga practice to ashtanga yoga (Cowen & Adams, 2005). Participants practiced either hatha or the more vigorous style of ashtanga yoga for six weeks. They were not looking specifically at strength gains but did find increases in dynamic trunk strength and endurance for both types. The size of the study was small (17 adults) and there was no control group, but it was a healthy population and the results are encouraging for more research in this area.

There is additional evidence supporting the idea that yoga has many health benefits (Ross & Thomas, 2010). Ross and Thomas (2010) did a review on the available research regarding yoga and exercise and overwhelmingly found that yoga can be as good as or better than many forms of exercise at improving many health measures including blood pressure, stress levels, and heart rate. The vast majority of the research in their review deals with ill populations or elderly participants, however it does support the idea that yoga has many health benefits to offer injured and/or elderly individuals.

Injuries, especially low back pain (LBP), often bring people to yoga (Sherman et al., 2005). LBP is third only to knee and ankle injuries in keeping athletes off the field (Gamble, 2007), affects 80% of the adult population (Bernard, 2006) and up to 57% of adolescents (Harringe et al., 2007). While LBP can often resolve itself without medical intervention, it has a recurrence rate of up to 90% and often for unidentifiable reasons (Kolber & Beekhuizen, 2007). Studies have examined the effectiveness of yoga as a treatment for LBP and have found much success (Sherman et al., 2005; Williams et al., 2005) but the reasons elucidating why yoga was so successful are not clear. Research shows that a lack of core strength and stability can be a leading cause of LBP (Leetun et al., 2004). A deficit in core strength can lead to disturbances throughout the kinetic chain making the lower back more susceptible to injury (Zazulak et al., 2007b). It's possible that yoga helps improve LBP as a result of increasing core strength but more research needs to be done to support this theory.

Williams et al. (2005) did a study looking at Iyengar yoga and the effects of a 16-week yoga training on low back pain. All the participants presented with low back pain and 48% used medication for it. The participants were divided into two groups: yoga interventions and control. The yoga group was taught 29 classic Iyengar poses that gradually were made more difficult as the participants progressed in their practice. At the end of the 16-week intervention the yoga group had significant reductions in pain and maintained those reductions at the three-month follow up. Additionally, 88% of the participants that were in the yoga group and had been on pain medication stopped taking the medication. This study is great because it actually lists all the poses the intervention group practiced during the study so it is easy to reproduce in a real life setting. While this study was not looking for strength gains, it's relevant because it shows Iyengar can be useful in relieving lower back pain, an issue facing many people.

In a similar study comparing the effects of yoga, exercise and a self-care book on adults who presented with chronic low back pain, Sherman et al., (2005) divided 101 participants into three groups. The participants completed 12-week sessions of either yoga, conventional therapeutic exercise, or a self-care book. At the start, at six, 12 and 26 weeks the patients were evaluated with a phone interview regarding low back pain and daily limitations that were caused by low back pain, totaling 23 questions. A secondary questionnaire was used regarding general health and medication usage. The study found that yoga was most effective at reducing low back pain as compared to the exercise and self-care book groups. And it was most effective at maintaining the benefits at least up to 26 weeks. This study also listed all the yoga poses used in addition to supplying pictures. The style of yoga used is called viniyoga and is generally used for therapeutic purposes (Sherman et al., 2005).

In a British study on yoga for chronic low back pain, Tilbrook et al. (2011) found that yoga was an effective means of improving back function and relieving low back pain. They recruited 313 adults and divided them into two groups, a yoga intervention group (N = 156) and a "usual care" group (N = 157). The intervention group participated in 12 yoga classes over the course of 12 weeks. The yoga group had better back function at three, six and twelve months based on results of their scores on the Roland-Morris Disability Questionnaire. This study showed positive results but again failed to elucidate the reasons why the yoga practice was more effective than "usual care". It is clear that yoga is effective at relieving low back pain, however there is minimal research to illustrate any strengthening benefits that might be gained from the practice of yoga which may be one of the reasons it is so effective at helping people with LBP.

Performance-Related Fitness Components

Performance-related fitness components are balance, speed, agility, power and motor skill. Balance is the ability to maintain a position without moving for a specific period of time. Speed is defined as distance/time: how fast a person can travel in a certain amount of time. Agility is the ability to explosively change movement velocities or modes. Power is the rate of doing work, measured as the product of force and velocity. It is the work achieved in a unit of time and is a combination of strength and speed. Motor skill is tack specific. It is a combination of balance, agility and coordination focused on a specific goal or task, generally developed over time (Baechle & Earle, 2008). The current study examined the effects of a yoga training on dynamic balance and power. Yoga has been shown to have a positive effect on static balance (Hart & Tracy, 2008) and, as power has an inherent strength component, it seemed logical to observe the effects yoga training may have on power.

Balance Performance. While balance is considered a performance-related fitness component, it is an important aspect of health and injury prevention as well (Hrysomallis, 2007; Myer et al., 2005). Several studies examined the effects of improved balance on of injury prevention. Filipa, Byrnes, Paterno, Myer, and Hewett (2010) worked with female soccer players in an effort to improve their scores on the star excursion balance test. The star test is used as a classification tool to determine a person's dynamic stability, assess deficits following an injury and to determine if a person is at high risk of a lower extremity injury. The neuromuscular training utilized in this study included core stability and lower extremity strength training, two times a week for eight weeks. Significant improvement in their star scores was found at the end of the study. Their goal was to find a training modality that would lend itself to injury prevention using the star test as the benchmark guide and they were successful. Results indicated that improved core strength and stability can be beneficial to improving balance but that further study was needed to determine if these improvements would actually lead to injury prevention.

Many studies, like the study mentioned above, deal with improving balance with the idea that it helps prevent injuries. A study done by Malliou, Gioftsidou, Pafis, Beneka, and Gofolias (2004) looks at actual injury rate in soccer players after undergoing balance training. They divided a group of 100 soccer players into two groups, treatment and control. The treatment group underwent twenty minutes of proprioceptive balance training twice a week and both groups were tracked for injury rates during the season. The treatment group had significantly less lower extremity injuries than the control. This study showed that specific balance training can help to prevent injuries in soccer players, and theoretically athletes in other sports as well.

A similar study by Emery, Rose, McAllister, and Meeuwisse (2007) looked at the effect of balance training on 920 high school basketball players. They were also divided into two groups. Both groups were taught a basic warm up program but the treatment group was also taught a basketball specific balance warm up. Their injuries were tracked by team trainers or therapists, who were blinded to the group assignments, throughout the season. Their findings indicated that a basketball specific balance training program is effective in preventing acute onset injuries. Their results were consistent with the results of several other studies examined in a review article by Padua and Marshall (2006). They looked at evidence supporting ACL injury prevention programs that all included balance training as part of their protocol and concluded that these training programs were effective at preventing ACL injuries. Clearly there is ample support for the idea that improved balance is an important aspect of injury prevention in athletes, but it is also important for healthy adults over the life span? For example, balance tends to decline as we age and is a major cause of falling in older adults and also a major component of the successful performance of simple daily tasks and recreational activities (Howe, Rochester, Neil, Skelton, & Ballinger, 2011).

While balance is classified as an aspect of performance-related fitness, there is some controversy as to how effective balance training is on improving performance. Certainly it's imperative to completing daily activities, of that there is little debate, but its impact on actual performance is still in question. A comprehensive review done by Zech et al. (2010) looked at twenty studies that used balance training as a means to improve neuromuscular control and functional performance. They found that while balance training is effective at improving areas of injury prevention such as postural sway and dynamic balance, its effect on performance variables like jumping and agility are slight. They concluded that in order to achieve optimal performance enhancement, balance training should be incorporated as part of a larger, more comprehensive training program.

A review of balance ability and athletic performance by Hrysomallis (2011) found that across sports, elite athletes tended to have better balance than their less experienced counterparts. Some studies found relationships between adding balance training components to the activities of recreationally active people and improvements in agility and vertical jump. However, in elite athletes, they found that resistance training offered more performance enhancing effects (vertical jump and sprint time) than did balance training. Still, this review demonstrates that for the average person, improving balance is a good way to improve power and agility. Hrysomallis concluded that balance training is a worthwhile addition to the training regimes of healthy adults.

Effects of Yoga on Balance Performance. Balance is an important factor in injury prevention and athletic performance for elite and recreational athletes alike. Performance enhancement via better balance is another way yoga is promoted and a reason people give for coming to yoga (Macklin, 2010; Sherman, 2002). It is a major claim among popular media and one that is repeated often as evidenced by the health club claims cited above. However, there is scant empirical evidence to support such claims. Oken et al. (2006) examined the effects of a six-month yoga training on quality of life in healthy seniors. The yoga intervention produced significant improvements in various quality life measures, including balance. These improvements were not seen in the exercise or the control group.

A 2008 study by Hart and Tracy looked at a Bikram yoga practice and its effects on motor variability in young adults. There were a total of 21 participants divided into two groups, yoga training and control. They performed a 90-minute Bikram (yoga practiced in a room heated to 103 degrees) yoga practice three times a week for eight weeks. At the end of the yoga-training period they found significant improvements in timed, standing balancing as compared to the control group which showed no change. These findings differ with another study using high school aged females. Donahoe-Fillmore et al (2010) compared seven-week yoga training with a walking intervention and found no improvements in balance. However, the limitations to this study was that the yoga training was only twice a week for 30-40 minutes and the static tests used were performed to nearly maximum ability at the outset of the intervention, leaving little room for improvement. Based on these findings, it's clear that additional research needs to be done to determine if yoga training would have a positive effect on balance. It would also be more relevant to performance to use more dynamic balance tests such as the single leg squat and the star excursion balance tests.

Power. The final two aspects of performance fitness tested in the current study are power and agility. Many studies have examined the importance of power in relation to athletic performance (Cormie, McGuigan & Newton, 2011; Cronin & Sleivert, 2005; Smirniotou et al., 2008) and also in functional performance (Rice & Keogh, 2009). Its significance is undisputable. As previously cited, improved balance has been shown to be a contributing factor to improvements in power (Hrysomallis, 2010). As there is some evidence that a yoga training can improve balance (Hart & Tracy, 2008), it might be enlightening to see if a yoga training would show increases in power. However, to date there are no studies examining the effects of yoga on these two areas.

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Appendix A

Figures and Tables

Figure 1. Sequence of 18 Poses within the Surya Namaskar B (Sun Salute)

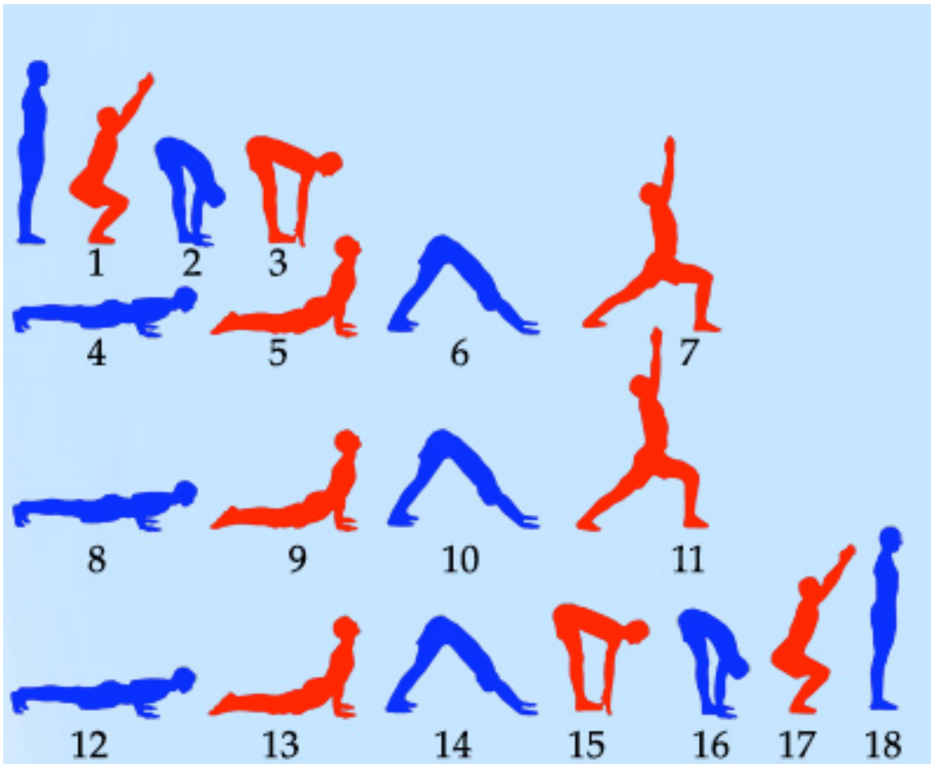


Illustration of the Surya Namaskar B sequence traditionally used in Vinyasa yoga classes, repeated three to five times. Classically, it is performed with one breath per movement, beginning with an inhale. As a warm-up, Surya Namaskar B typically follows three to five repetitions of Surya Namaskar A, which incorporates only poses 2-6, 15, 16 and 18.

Figure 2. Virabhadrasana III (Warrior) Pose

A vigorous yoga pose commonly used in a Vinyasa yoga class that requires some flexibility of the hamstring muscles and strength of the medial thigh and lateral hip muscles of the support leg. In addition, strength/endurance of core musculature is used to help support the spine and maintain balance.

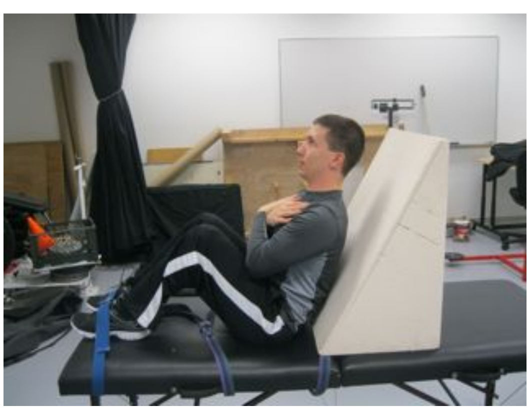
Figure 3. Star Excursion Balance Test

Participant reaches as far as possible with the lifted leg and taps the mat while maintaining balance on the support leg.

Figure 4. Counter Movement Vertical Jump

From standing, the subject uses a full preparatory arm swing, jumps as high as possible, and reaches and touches the highest marker on the Vertec.

Figure 5. Flexor Test



Support wedge is removed and the participant maintains a flat back, wide chest and the torso at the starting angle of 60 degrees until failure. Test is used to evaluate the muscular strength/endurance of the flexor muscles of the abdominals (iliopsoas).

Figure 6. Extensor or Modified Biering-Sorensen Test

The participant maintains the torso at the same height as the hips until failure. Test is used to evaluate muscular strength/endurance of the extensor muscles of the spine and back.

Figure 7. Side Bridge

While balancing on the forearm, the participant lifts the hips and thighs off the table and maintains the lifted position until failure. Test is used to evaluate the muscular strength/endurance of the obliques and low back (specifically quadratus lumborum).

Figure 8. Mean Performance on Combined Star Excursion Test

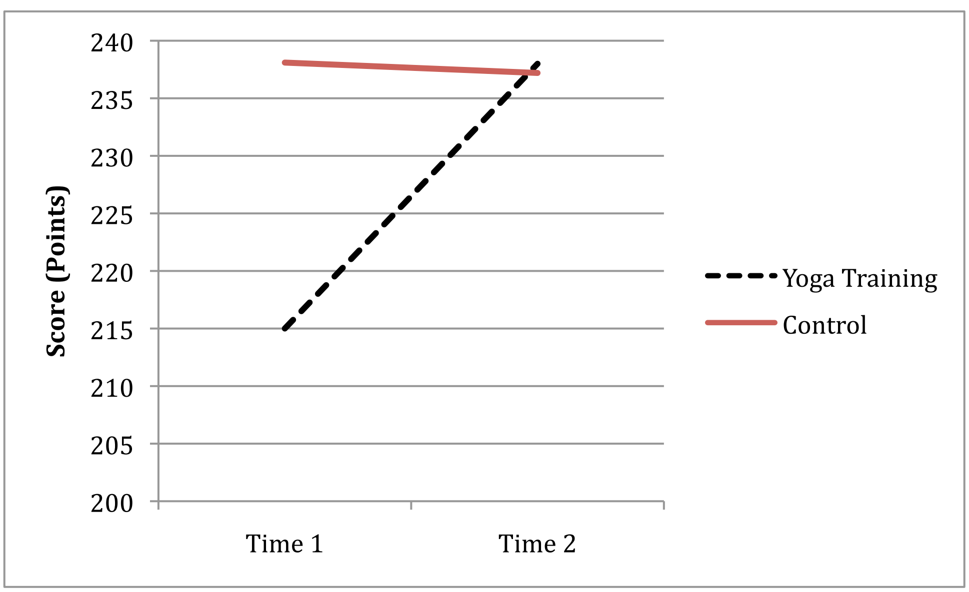


Figure 9. Mean Performance on Countermovement Vertical Jump

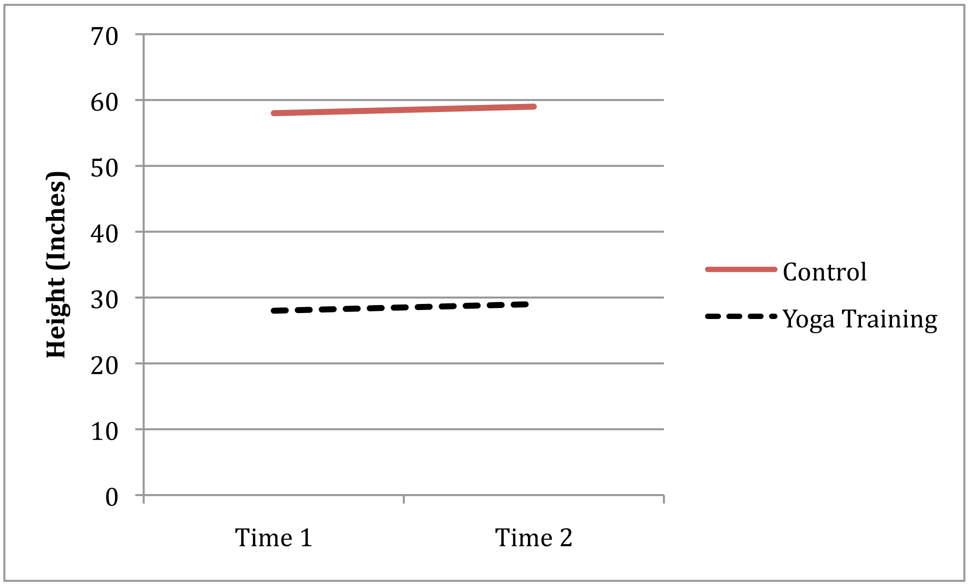


Figure 10. Mean Performance for Anterior Core Muscular Strength/Endurance

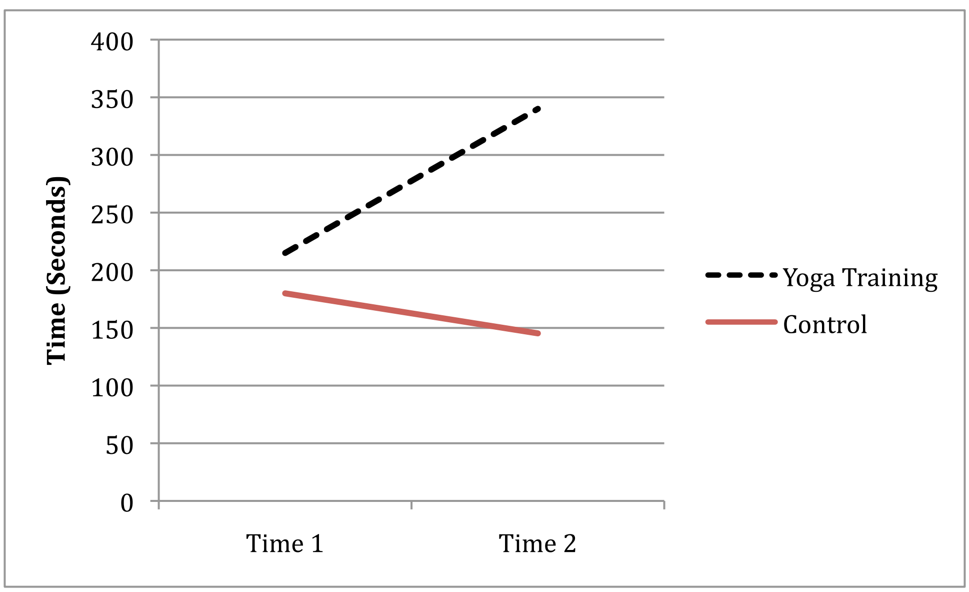


Figure 11. Mean Performance for Posterior Core Muscular Strength/Endurance

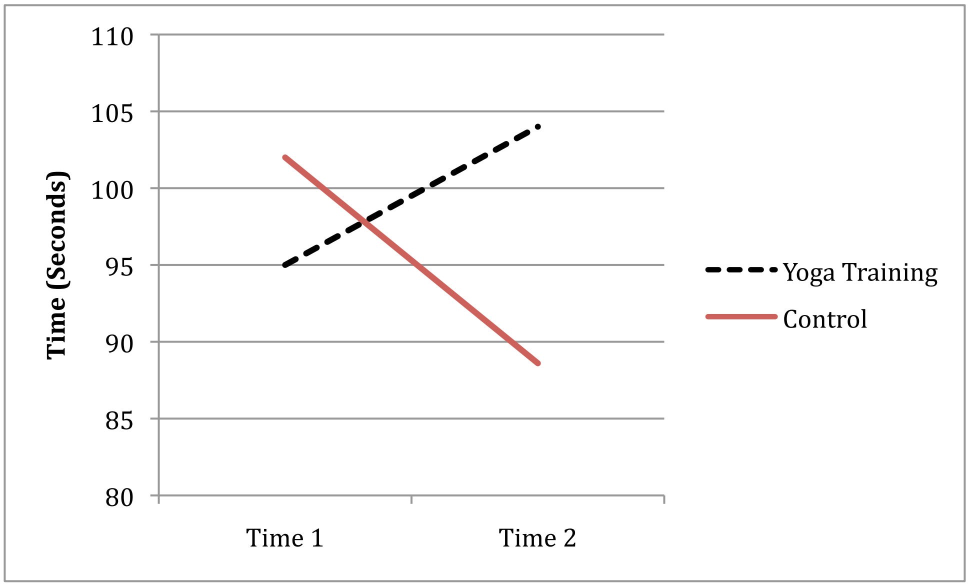


Figure 12. Mean Performance for Lateral Core Muscular Strength/Endurance

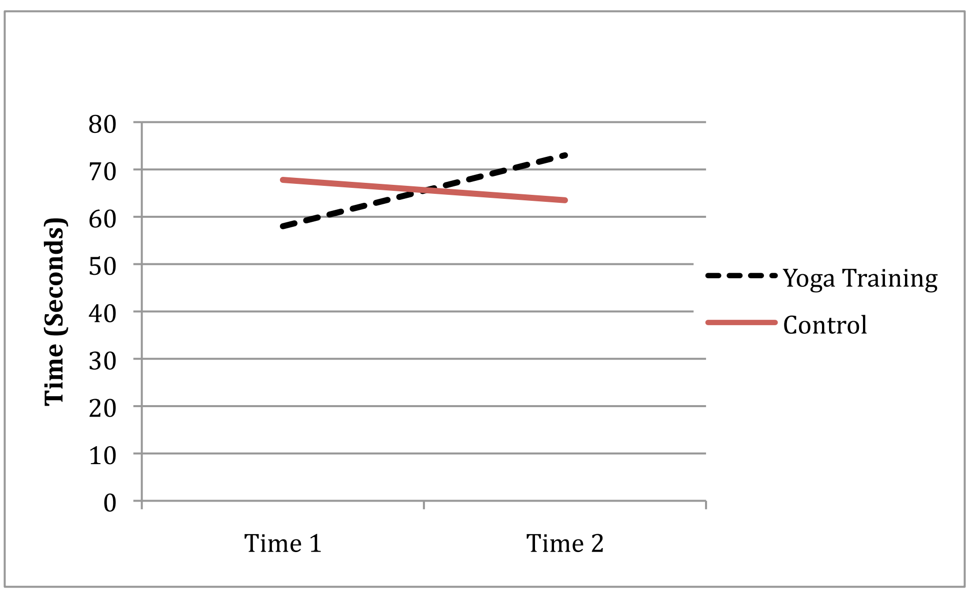


Table 1.

Average Percent (and SD) of Classes (n = 24) Attended by Training Participants

	M (%)	SD (%)
Home	83	25
Class	91	9
Total	88	11

Table 2.

Mean (and SD) Participant Characteristics by Group

	Training (n =15)		Control (n =16)	
	M	SD	M	SD
Age (yr)	22.3	4.6	26.1	7.0
Height (in)	65.3	5.2	66.6	2.9
Weight (lbs)	145.4	42.7	153.3	29.0

Table 3.

Mean Group Performance on Star Excursion (points), CMVJ (inches), and Flexor, Extensor, and Side Bridge (in seconds) Across Time

	Yoga Training		Control	
	Time 1	Time 2	Time 1	Time 2
Variable	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Stare Excursion	215.0 (23.0)	238.0 (22.7)	238.1 (31.7)	237.2 (30.3)
CMVJ	28.0 (7.8)	29.0 (6.4)	30.0 (7.2)	29.8 (7.4)
Flexor Test	215.0 (105.2)	340.0 (131.7)	180.0 (153.0)	145.3 (91.6)
Extensor Test	95.0 (40.5)	104.0 (39.2)	102.0 (49.0)	88.6 (39.3)
Side Bridge Test	58.0 (29.8)	73.0 (33.7)	67.8 (38.8)	63.5 (25.8)

Appendix B

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

THE EFFECTS OF VINYASA YOGA PRACTICE ON SEVEN TESTS OF HEALTH AND PERFORMANCE FITNESS IN AN ADULT POPULATION

PARTICIPANT INFORMED CONSENT FORM – PRACTICE GROUP

Introduction

This study, conducted by Christine LaMonica Inniss as part of the Master of Science requirements in the department of Kinesiology at California State University, Northridge, examines the changes in strength and endurance of core (trunk) muscles and four additional measures of performance fitness over an eight-week period.

Description of Research

Specifically, my study is designed to examine whether or not practicing eight weeks of yoga (3 times per week) strengthens the core (or trunk) muscle groups (i.e. tranverse abdominus, rectus abdominus, erector spinae, and internal and external obliques) and improves performance in balance, motor control, power and agility tests. To participate in this study, you must: (a) be at least 18 years of age, (b) have no more than 6 months of yoga experience (i.e. you are more of a beginner), (c) not be pregnant or planning to be pregnant in the next eight weeks, and (d) have no positive responses to a basic health status questionnaire.

If you meet all of the above inclusion criteria for the study and you choose to participate, you will be asked to complete two 45-minute testing sessions (one before and one after the eight-week program). Testing sessions involve measuring the muscular strength and endurance of some of your core muscles as well as four areas of performance fitness. In addition, for eight weeks, you will be asked to participate weekly in two 90-minute yoga practice classes in Redwood Hall and one 45-minute home practice. For the home practice, you will receive a DVD to follow. You will also be asked to provide weekly feedback regarding the classes you attend and your compliance with home practice, including your perceived effort during each practice.

Participation Risks

Some risk is involved with any form of physical activity or exercise. Risks associated with exercise testing or practicing yoga, for example, may include fatigue, muscle soreness, and more serious injuries such as muscle strains or sprains. To mitigate the risk of injury, a qualified yoga instructor will conduct the testing and teach the weekly yoga classes. The home practice will be based on these classes so the poses will be familiar. You will also receive a DVD to aid in proper performance at home. In the event that an injury does occur, you will be referred to either the campus health center if you are a current CSUN student, or your personal physician, at your own cost.

Confidentiality and Final Disposition of Data

Any information that is collected in this study that can be identified specifically to you will remain confidential and disclosed only with your written permission or if required by law. The cumulative results of the study may be published, but neither your name nor your identity will be known. All documentation collected as a part of this study will be kept in a secure location for five years at which time the data will be destroyed.

Benefit of Participation

The primary benefits for participating in this study may be the numerous health-related benefits from practicing yoga, e.g. improved flexibility, reduced stress. At no cost, and for eight weeks, you will receive two 90-minute weekly yoga practice sessions led by a qualified yoga instructor.

Concerns

If you wish to voice a concern about this research, you may direct your questions to Research and

Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA, 91330-8232, or phone 818-677-2901. If you have specific questions about the study, you may contact Dr. Jennifer L. Romack, 18111 Nordhoff Street, Northridge, CA 91330-8287, or phone 818-677- 3219.

Voluntary Participation

Your choice to participate in this study is completely voluntary. You may decline to participate or during the course of the study you may withdraw at any time without jeopardy. Likewise the researcher may cancel this study at any time. A copy of your informed consent will be stored in a locked filing cabinet and you will be given a copy of this informed consent for your records.

Videotaping

During the course of the project participants will be videotaped. Your initials here ____signify your consent to be videotaped. All recordings collected as part of this project will be kept on file by the researcher at the conclusion of the study.

I have read the above and understand the conditions for participation in the described study. I understand that in no way does signing this form remove any of my legal rights nor does it relieve the investigators, sponsors or involved institutions from their legal and professional duties. I give consent to participate in the study.

Your Name: ____
(please print) Last First MI

Phone Number: ____________________________________

Email Address: ____________________________________

Your Signature: ______________________________ Date ____________

Witness/P.I. Signature: ________________________ Date ____________

CSU, Northridge
Human Subjects Committee
Approved: 9/1/11
Void After: 8/22/12

CSU, Northridge
Human Subjects Committee
Approved: 9/1/11
Void After: 8/22/12

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

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Description of Research

To participate in this study, you must: (a) be at least 18 years of age, (b) have no more than 6 months of yoga experience (i.e. you are more of a beginner), (c) not be pregnant or planning to be pregnant in the next eight weeks, and (d) have no positive responses to a basic health status questionnaire. If you meet all of the above inclusion criteria for the study and you choose to participate, you will be asked to complete two 45-minute testing sessions (one at the start of the study and one eight weeks later). Testing sessions involve measuring the muscular strength and endurance of some of your core or trunk muscle groups (that is, the tranverse abdominus, rectus abdominus, erector spinae, and internal and external obliques) as well as four areas of performance fitness.

Subject Information and Risks

Some risk is involved with any form of physical activity or exercise. Risks associated with exercise testing may include fatigue, muscle soreness, and more serious injuries such as muscle strains or sprains. To mitigate the risk of injury, a qualified yoga instructor will conduct the testing. In the event that an injury does occur, you will be referred to either the campus health center if you are a current CSUN student, or your personal physician, at your own cost.

Confidentiality & Final Disposition of Data

Any information that is collected in this study that can be identified specifically to you will remain confidential and disclosed only with your written permission or if required by law. The cumulative results of the study may be published, but neither your name nor your identity will be known. All documentation collected as a part of this study will be kept in a secure location for five years at which time the data will be destroyed.

Benefit of Participation

You will not receive monetary compensation for participation in this study. However, after the post-testing, you will receive five 90-minute yoga classes, free of charge, at a local yoga studio (North Valley Aikikai). This offer will expire six months after the date of your post-testing.

Concerns

If you wish to voice a concern about this research, you may direct your questions to Research and Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA, 91330-8232, or phone 818-677-2901. If you have specific questions about the study, you may contact Dr. Jennifer L. Romack, 18111 Nordhoff Street, Northridge, CA 91330-8287, or phone 818-677- 3219.

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Your choice to participate in this study is completely voluntary. You may decline to participate or during the course of the study you may withdraw at any time without jeopardy. Likewise the researcher may cancel this study at any time. A copy of your informed consent will be stored in a locked filing cabinet and you will be given a copy of this informed consent for your records.

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I have read the above and understand the conditions for participation in the described study. I understand that in no way does signing this form remove any of my legal rights nor does it relieve the investigators, sponsors or involved institutions from their legal and professional duties. I give consent to participate in the study.

Your Name: ____

(please print) Last First MI

Phone Number: ____

Email Address: ____

Your Signature: ________________________________ Date ______________

Witness/P.I. Signature: __________________________ Date ______________

CSU, Northridge
Human Subjects Committee
Approved: 9/1/11
Void After: 8/22/12

Appendix C

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their physician before they start becoming more physically active. Please complete this form as accurately and completely as possible.

PAR-Q FORM Please mark YES or No to the following: YES NO

Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity? ____ ____

Do you frequently have pains in your chest when you perform physical activity? ____ ____

Have you had chest pain when you were not doing physical activity? ____ ____

Have you had a stroke? ____ ____

Do you lose your balance due to dizziness or do you ever lose consciousness? ____ ____

Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed when developing an exercise program (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, anorexia, bulimia, anemia, epilepsy, respiratory ailments, back problems, etc.)? ____ ____

Are you pregnant now or have given birth within the last 6 months? ____ ____

Do you have asthma or exercise induced asthma? ____ ____

Do you have low blood sugar levels (hypoglycemia)? ____ ____

Do you have diabetes? ____ ____

Have you had a recent surgery? ____ ____

If you have marked YES to any of the above, please elaborate below:

____

____

____

Do you take any medications, either prescription or non-prescription, on a regular basis? Yes/No

What is the medication for?

How does this medication affect your ability to exercise or achieve your fitness goals?

____

____

____

Please note: If your health changes such that you could then answer YES to any of the above questions, tell your trainer/coach. Ask whether you should change your physical activity plan.

I have read, understood, and completed the questionnaire. Any questions I had were answered to my full satisfaction.

Print Name: ______________________________ Signature: ____________________________________

Date: ____________________________________

Appendix D

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Baecke Questionnaire of Habitual Physical Activity

1. What is your main occupation?
   ____
2. At work I sit
   never/seldom/sometimes/often/always________________
3. At work I stand
   never/seldom/sometimes/often/always________________
4. At work I walk
   never/seldom/sometimes/often/always________________
5. At work I lift heavy loads
   never/seldom/sometimes/often/very often_____________
6. After working I am tired
   very often/often/sometimes/seldom/never_____________
7. At work I sweat
   very often/often/sometimes/seldom/never_____________
8. In comparison with others my own age I think my work is physically
   much heavier/heavier/as heavy/lighter/much lighter_____
9. Do you play sport?
   yes/no
   If yes:
   -which sport do you play most frequently?__________
   -how many hours a week?___________
   -how many months a year?__________

If you play a second sport:
   -which sport do you play most frequently?__________
   -how many hours a week?___________
   -how many months a year?__________

10. In comparison with others my own age I think my physical activity during leisure time is
    much more/more/the same/less/much less____________
11. During leisure time I sweat
    very often/often/sometimes/seldom/never____________
12. During leisure time I play sport
    never/seldom/sometimes/often/ very often____________
13. During leisure time I watch television
    never/seldom/sometimes/often/ very often____________
14. During leisure time I walk
    never/seldom/sometimes/often/ very often____________
15 During leisure time I cycle
    never/seldom/sometimes/often/ very often____________
16. How many minutes do you walk and/or cycle per day to and from work, school, and shopping?
    <5/5-15/15-30/30-45/>45________________________