

ELECTROMYOGRAPIC ACTIVITY IN CORE MUSCLES DURING STATIC  
YOGA POSES PERFORMED ON STABLE AND UNSTABLE SURFACES

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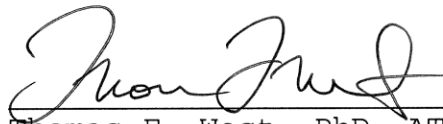
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## INTRODUCTION

Yoga has become a popular exercise among those deemed physically active, simply because it lacks the age restrictions that accompany other exercise types, offers exercise versatility, and has the potential to target multiple systems without additional exercise equipment. Since research has indicated the benefits of core muscle recruitment, Yoga appears to encompass constant core contracture during controlled deep breaths; if this activity is maintained throughout the entire pose. This component is important, because the core helps maintain posture during walking, assists in spine stabilization and is instrumental in various sport actions.<sup>1-5</sup>

In addition to the benefits of core stabilization, Yoga also incorporates balance and stabilization during Yoga poses. This occurs because the muscles must contract to maintain balance, which leads to strengthening via increased motor neuron recruitment.<sup>3</sup> Since Yoga contains dynamic versatility, the individual is able to perform the activity to their level of capability and build strength based on the pose performed. This type of exercise is also cost effective, low impact, supplies versatility, targets



multiple systems, and functions as a stress reliever via endorphin release during deep controlled breathing.<sup>6,7</sup>

However, there may be several conditions necessary to perform Yoga safely; to achieve the desired benefit of muscular strength and endurance. For example, a participant must have adequate balance and be able to stand. This is necessary because Yoga requires participants to maintain constant muscle contractions throughout the duration of the pose. In addition, a participant who progresses from beginner to advanced may possess the potential of creating a dynamic workout. This workout may be achieved through continuous repetition of various poses' without rest. This format of Yoga training is comparable to circuit exercises, which are designed to target the participant's heart rate. When Yoga is utilized to its full potential, it is possible for the participant to receive a relatively low impact exercise designed to meet the individual's goal for their desired level of fitness. This is a component that may offer the participant, athletic trainer, or other health care professional; the opportunity to introduce Yoga into their fitness or rehabilitation regimen.

Athletic trainers can take advantage of other techniques in their exercise selection. Several studies have indicated instability during exercise encourages

increased electrical activity in muscles. This activity occurs because the enhanced volatility and movement requires an increase in motor unit recruitment to maintain stability and balance.<sup>3</sup> Therefore, it may be concluded that a combination of Yoga and surface instability may lead to potential changes in participants of this exercise.

Research has also provided scientific evidence to support the theory of instability through use of perturbations, which may be described as the disturbance of motion.

Therefore, it appears the state of equilibrium on unstable surfaces has the potential to increase the amount of muscular activity for the participant.<sup>8-12</sup>

The majority of the research examined concerning increased muscular activity through unstable surfaces focused on the core muscles, such as the rectus abdominus, external oblique and erector spinae. In some cases, which relied on the placement of electrodes; the internal oblique and the transversus abdominus were also recruited. In comparison to total muscle recruitment, the rectus abdominus appeared to have a higher increase in activity in comparison to the other muscles. However, the increase in muscle activity relied on the type of exercise performed by the participant. Additionally, while most results studied indicated an increase in muscular contractions, several

other studies failed to produce a significant increase in muscular contraction or none at all. This inconsistency may have been due to poor participant selection, lack of balance, poor muscle tone, unfamiliarity with the pose, poor electrode conduction, or other unknown factors.<sup>13,14</sup>

While other researchers focused on specific muscles in single poses, Norwood et al investigated instability training and the muscle recruitment of the core during dynamic multi-joint movement. He examined six muscles and four exercises were used to test the latissimus dorsi, rectus abdominus, internal oblique, erector spinae, biceps femoris and soleus. EMG recorded activity levels for five seconds, indicated significant increases in EMG activity with the introduction of instability. These results may indicate use of dynamic multi-joint movement as the means to enable the most muscle recruitment on unstable surfaces.<sup>8</sup>

While Norwood et al focused on major core muscles during four varied exercises with multi-joint movement as the best means of muscle recruitment, Petrofsky et al used a slightly different protocol. Petrofsky et al examined muscle use during core body exercise with a mini-stability ball compared with abdominal crunches. He compared data between these two variables utilizing three levels of core exercises. The results of this study concluded the mini-

stabilization ball required 50 percent more muscle activity in comparison to standard crunches.<sup>12</sup>

Moreside et al, also found similar results as Norwood through introduction of stabilization and perturbations. Moreside et al incorporated trunk muscle activation patterns, spine kinematics, and lumbar compressive forces that produce perturbations via the Bodyblade®. The addition of this equipment produced the greatest muscle activation in the internal and external oblique muscles and not the rectus abdominus. This variation in results may have been due to the use of upper extremities to create the movement and produce the instability.<sup>15</sup>

Marshall and Murphy utilized another approach to their research. Their study examined the differences in electromyographic activities in prime movers, specifically the anterior deltoid, biceps brachii, triceps brachii, pectoralis major, rectus abdominus, transversus abdominus, and internal oblique, while performing certain exercises. The results of this study indicated there was no significant difference between muscle activity and surface while a participant performed squats on stable surfaces. However, the muscular activity in the triceps and abdominals indicated a significant increase in muscle recruitment on unstable surfaces during push-ups on the

Swiss ball. This data may conclude the muscles used for recruitment is affected by the type of instability that occurs.<sup>10</sup>

In addition, a study conducted by Willardson et al, researched surface stability and its correlation to muscle activation and found similar results as in previous studies. His findings indicated muscle activity increases during unstable conditions. His study focused on examining core muscle activity on stable ground and on an unstable surface (BOSU Balance Trainer®). Four exercises were used to examine the muscle activity, incorporating the rectus abdominus, internal and external obliques, erector spinae, and the transversus abdominus. The participants were given a specific exercise and were instructed to perform the exercises at 50 percent intensity on stable and unstable surfaces, and repeat the same exercises at 75 percent intensity on stable surfaces. The results of his study concluded there was no significant difference in muscle activation in the core muscles he targeted regardless of the surface.<sup>13</sup>

In conclusion, of the literature examined for this study, most researchers focused on the core stabilizing muscles of the abdominal area. Although several studies concentrated on prime movers of the upper extremities, it

appears most research supports the theory of increased muscular contraction and electrical activity in muscles that are recruited to perform exercise on unstable surfaces.<sup>8-14</sup> Additional research is certainly warranted, given the results reviewed by the researcher. Even though Yoga appears to be an alternative option to physically active participants in all ages with minimal risk, I plan to investigate if optimal results may be achieved through this method on stable versus unstable surfaces. Since variation in data already exists, I plan to place controls on selection of participants and criteria for the type of pose, length of pose and surface for the data collection. Therefore, the purpose of this study will be focused on analyzing the EMG activity in the core muscles during specific poses on stable and unstable surfaces.

## METHODS

The primary purpose of this study was to examine EMG activity of the rectus abdominus, external oblique and erector spinae during static Yoga poses on stable and unstable surfaces. This section includes the following subsections: research design, subjects, preliminary research, instruments, procedures, hypotheses, and data analysis.

### Research Design

This research was a quasi-experimental, within subjects, repeated measures design. The independent variables were Yoga poses with three levels, each pose varying in level of difficulty, and surface stability condition with two levels, stable and unstable. The Yoga poses including 3 static Yoga poses consisting of one beginner pose, an intermediate pose, and an expert pose. The surface stability condition consisted of the stable and unstable surface. The stable surface was solid ground on a concrete floor. The unstable surfaces were on a foam surface and BOSU (Both Sides Up) ball. The dependent

variable was the peak EMG activity measured in the rectus abdominus, external oblique, erector spinae and reported as a percentage of the maximal voluntary contraction (%MVC).

### Subjects

The examiner received approval to conduct the study from the California University of Pennsylvania Institutional Review Board (Appendix C1). The examiner proceeded to recruit volunteer subjects via announcements made by the researcher in the California University of Pennsylvania Health Science classes. All subjects signed and dated an Informed Consent Form (Appendix C2) prior to participation in the study. Each participant's identity remained confidential and was not included in the study. There were 17 subjects that volunteered for this study. The subjects were physically active male and female, college aged, students.

The examiner explained the purpose of the study to the students in two classes: Athletic Training Clinical Education II and Orthopedic Evaluation in Sports Medicine. The subjects were notified of the procedures and protocols necessary to complete the study. The subjects were also



informed of all possible dangers and benefits of the experiment.

The researcher explained the inclusionary and exclusionary criteria which included, having no balance problems, vertigo, taking any medications that could cause any of the above mentioned problems, and being physically active. Physically active was defined as participating in some form of exercise for a minimum of thirty minutes at least three times per week.

Once the announcements and introductions to the study were made, the examiner distributed the demographic sheet (Appendix C3) to all students in the classroom class to fill out. The demographic sheet contained questions about any medical problems causing balance problems and it questioned the subjects' physical activity.

Once the demographic sheet was completed, the examiner reviewed the potential subject's information to look for any red flags. The red flags for the study were subjects who had balance problems created by previous injury, medication, and medical problems. Another red flag was whether or not the potential subjects met the minimum thirty minute, three times per week exercise requirement. If any of the potential subjects had red flags, the

examiner notified the subjects of their exclusion from the study.

Once participants were identified, a sheet of paper was handed out to the class. The (participants) subjects were asked to write down their names, email addresses, days and times available to participate in the study. The subjects that signed the sheet were informed they would receive an email within the next day consistent of names, dates and times of when the study would be conducted. Prior to exiting the classroom, the researcher notified the subjects that they had the option of resigning from the study without any repercussions prior to beginning the study.

Each subject participated in a 5 minute warm-up session consistent of 1 minute of biking and then for the additional 4 minutes, the subjects completed 3 step by step Yoga Sun Salutations. The warm-up was performed before the study to warm the muscles and reduce the chance of injury. Then the subjects proceeded to participated in the 30 minute exercise program.

The exercise program consisted of completing a maximal voluntary contraction 3 times for each individual muscle. The subjects were shown the way to perform each individual MVC test by the examiner. The purpose of the MVC (maximal

voluntary contraction) was to obtain the muscles' maximum muscle activity. The MVC allowed for a basis of comparison for the muscle activity during the Yoga poses. The comparison dictated whether or not the Yoga poses targeted the muscles' maximum contraction.

The subjects were instructed on how to properly perform each Yoga pose; then the subjects completed the 3 designated Yoga poses, the Tree pose, Boat pose, and Side Plank pose on the stable and unstable surfaces. The subjects completed two trials of the Yoga poses during the 30 minute exercise protocol. The subjects were instructed to perform a cool-down consisting of stretching at the end of the exercise program.

#### Preliminary Research

A pilot study was conducted with this research project. The students with the aforementioned requirements entered the California University of Pennsylvania athletic training lab and reviewed the steps needed in order to perform the experiment. The procedure began with the subjects performing a warm-up program and concluded with the designed experimental exercise. The warm up program consisted of 1 minute of biking. The subjects proceeded to

complete three sets of Yoga poses called Sun Salutations for the remaining 4 minutes of the warm up. Then the subjects proceeded to select the order of Yoga poses to be performed via counterbalanced random assignment.

The researcher instructed the subjects to perform maximal voluntary contraction tests for the rectus abdominus, external oblique and erector spinae consisting of a standard crunch for the rectus muscle, a crunch with external rotation, and a back extension referred to as the superman, prior to beginning the exercise protocol. The subjects were required to hold the abdominal crunch, abdominal crunch with external rotation, and the back extension positions for five seconds. As the subject held the positions, the examiner applied resistance trying to push the subject in the opposite direction.

Next, the subjects were allowed a five second rest period before the subject completed two additional five second MVCs. Each individual subject had 30 seconds to complete three MVCs(maximal voluntary contractions), for each of the three muscles, each contraction lasting five seconds. The average of their maximal voluntary contraction was used in comparison to the electrical activity recorded during the Yoga poses which were held for fifteen seconds. During the process, the researcher determined the subjects'

ability to understand the assigned protocol, whether the subjects had the capability to complete the warm-up protocol, and the peak electrical activity of the rectus abdominus, external oblique, and erector spinae contracture during the experiment. The data was saved on the laptop under the Acqknowledge software. In order to separate the data, each subject's data was recorded in correspondence to the subject's number, pose number, surface condition, and trial number.

### Instruments

The data collection instrumentation used for this study consisted of EMG equipment, including a MP150 amplifier with wired telemetry unit connected to a PC running Biopac Acknowledge 4.0 software. Additionally a BOSU ball and foam pad was utilized along with a standard stop watch, ace wrap to secure the electrodes and prevent the EMG equipment from moving during the completion of the Yoga poses, and alcohol prep pads to remove any residue on the subjects preventing the electrodes from adhering to the skin.

## Procedure

There was a test trial conducted before the actual experiment occurred. The test trial consisted of the subjects completing each pose on each surface. The trial allowed for the subjects to familiarize themselves with Yoga before starting the actual testing. The subjects who volunteered for the experiment were given a sheet of instructions that described the experiment and the procedures needed to complete the exercises. After the subjects read the instructions, they were given a chance to ask questions or if the subjects chose not to participate, they had the opportunity to resign from testing.

There was a 5 minute warm-up consistent of biking for 1 minute to warm the muscles. Following the 1 minute biking, the subjects performed three various Yoga steps called Sun Salutations for the additional 4 minutes. The examiner performed each step with each individual subject and instructed the individual subjects to follow the examiner's step by step directions and movements. In order to ensure all subjects did not spend more or less time in one pose than the other, a stop watch was used to time 5 seconds between each Sun Salutation pose. In addition, a

voice recording indicating, to the subjects when to move, was utilized.

Once the warm-up was completed, the subjects proceeded to select which poses to complete on stable and unstable surfaces. The stable surface consisted of concrete and the unstable surfaces were a combination of a foam pad to stand on for the Tree pose and the BOSU ball for the subjects to sit on for the Boat and Side Plank poses. The order in which the subject completed the poses were chosen by doing a counterbalanced random assignment where the examiner separated the order of poses starting from beginner, intermediate, and expert until there were six possible choices.

Prior to selecting the order of yoga pose, the examiner cleaned the subject's corresponding muscle belly with an alcohol prep pad to remove excess dirt. This provided a better surface for the electrodes to adhere. Then the examiner placed the surface EMG electrodes over the muscle belly of the rectus abdominus, the external oblique, and the erector spinae on the subject's dominant side. The dominant side was indicated by the examiner asking the subject what was his or her dominant side. An additional ground electrode was placed below the ASIS (Anterior Inferior Iliac Spine) to reduce the

interference of electrical activity from other muscles. The examiner proceeded to wrap an elastic wrap around the subjects' torso to hold the Biopac and electrodes in place.

Before completing the Yoga poses, the subjects were required to perform a Manual Voluntary Contraction. The subject was instructed to perform a standard abdominal crunch for the rectus abdominus with legs extended. The subject held the end position as the examiner tried to push the subject into extension. For the external oblique, the subject performed an abdominal crunch using the subject's elbow and crossing over to the subject's dominant side for the external oblique. The subject held the end pose while the examiner tried to pull the subject in the opposite direction. For the erector spinae, the subject was on the stomach. The subject performed a back extension while the examiner tried to push the subject into flexion.

After retrieving the MVCs, the subjects began to perform the selected Yoga poses and perform the Yoga pose in the order chosen via counterbalanced random assignment. The subjects were instructed to start in the corresponding beginning phase then progress to the proper end phase of the exercise and hold the pose for 15 seconds. As previously done for the warm-up, a stop watch was utilized to ensure all subjects spend equal five second rest time



between poses. As the subject maintained the Yoga pose, the examiner documented the peak activity of each muscle on both surfaces for two trials.

The data was saved on the laptop the EMG software was located. The subjects' data was documented based on subject number, pose number, surface, and trial number. Each beginning phase varied based on the different Yoga pose. First, the subjects performed each pose on the surface selected during the counterbalanced random assignment. The poses were performed on the concrete ground for the stable surface and the BOSU ball and foam pad for the unstable surfaces depending on pose difficulty. The Tree pose was performed on the foam pad and the Boat pose and Side plank pose were both performed on the BOSU ball for the unstable surface.

Each subject completed 2 trials. Each trial consisted of the completion of the three Yoga poses on both stable and unstable surfaces. The subjects were given a five second rest period between each pose. The subjects completed the second assigned pose, followed by the third assigned pose on both stable and unstable surfaces. Once the subjects completed the first trial run, there was one additional trial run conducted. During, the second trial, the exact same procedures were followed. The two trials

were averaged and compared to the subject's percentage maximal voluntary contraction.

Once the two trials were completed and documented, the subjects were encouraged to do a 5 minute cool down. This activity consisted stretching the quadriceps, hamstrings and shoulders to minimize the chance of muscle soreness. After the experiment, the subjects were free to leave.

### Hypotheses

The following hypotheses were based on previous research and the researcher's intuition based on a review of the literature.

1. There will be an increase in EMG activity for all 3 muscles groups for all 3 Yoga poses under the unstable condition when compared to the stable condition.

The following sub-hypotheses will be tested to examine effects of Yoga pose and stability condition on each target muscle:

1. There will be an increase in EMG activity for the rectus abdominus for all 3 Yoga poses under the

unstable condition when compared to the stable condition.

2. There will be an increase in EMG activity for the external oblique for all 3 Yoga poses under the unstable condition when compared to the stable condition.
3. There will be an increase in EMG activity for the erector spinae for all 3 Yoga poses under the unstable condition when compared to the stable condition.

#### Data Analysis

All data will be analyzed by SPSS version 18.0 for windows at an alpha level of 0.05. The research hypothesis will be analyzed using a factorial repeated measures analysis of variance.

## RESULTS

The purpose of this study was to examine EMG activity of the rectus abdominus, external oblique, and erector spinae during static Yoga poses on stable and unstable surfaces. The EMG activity was measured using a MP150 amplifier connected to a laptop with the Biopac Acqknowledge 3.0 software. The following section contains data collected throughout the study and is divided into the following subsections: Demographic Information, Hypothesis Testing, and Additional Findings.

### Demographic Information

A total number of 17 physically active, college aged subjects volunteered to participate in the study. Physically active subjects were chosen to reduce the chances of injury compared to a sedentary subject suddenly completing exertional Yoga poses. These subjects were identified as such via the demographic information sheet being handed to the subjects, completed, and given back to the examiner. The subjects consisted of 5 males and 12 females, all of whom were 18 years or older, and college

undergraduates enrolled in California University of Pennsylvania. All subjects were physically active with the definition of physically active described as completing some form of exercise or exertional activity with the potential of raising the heart rate to the target heart zone and maintaining the condition for a minimal of 30 minutes and completing the activity at least three out of the seven days in a week. Subjects with inner ear problems, vertigo, major stability issues, weak joints, or subjects taking any form of medication causing balance or stability problems were not included in the study.

#### Hypothesis Testing

The initial test performed was a 2x3x3 factorial ANOVA (surface x pose x muscle) to examine if muscle had an interactive effect on peak EMG activity. The interaction between surface condition, pose and muscle was not significant ( $F(4,64)=.626, p=.646$ ). For this reason, three 2x3 factorial ANOVAs were computed, one for each muscle. Hypothesis 1 examined the effects on the rectus abdominus, hypothesis 2 on the external oblique and hypothesis 3 on the erector spinae.

Hypothesis 1: There will be an increase in EMG activity for the rectus abdominus for all 3 Yoga poses under the unstable condition when compared to the stable condition.

**Table 1.** Mean Normalized Peak EMG Activation for Rectus Abdominus during Yoga Poses and Different Surfaces

	Mean Peak EMG (SD)	
	Stable	Unstable
Tree	111% (82.3)	119% (99.3)
Boat	115% (73.6)	133% (101.0)
Side Plank	142% (125.2)	129% (107.5)

Conclusion 1: A 2x3 within-subjects factorial ANOVA was calculated comparing the percentage of activity in the rectus abdominus during 3 Yoga poses on two different surfaces. The main effect of surface was not significant ( $F(1,16)=1.149$ ,  $p=.300$ ). The main effect of pose was not significant ( $F(2,32)=1.879$ ,  $p=.169$ ). The interaction between surface and pose was also not significant ( $F(2,32)=2.018$ ,  $p=.150$ ).

Hypothesis 2: There will be an increase in EMG activity of the external oblique for all 3 Yoga poses under

the unstable condition when compared to the stable condition.

**Table 2.** Mean Normalized Peak EMG Activation for External Oblique during Yoga Poses and Different Surfaces

	Mean Peak EMG (SD)	
	Stable	Unstable
Tree	123% (104.2)	124% (125.5)
Boat	133% (180.9)	153% (169.6)
Side Plank	164% (189.1)	143% (139.5)

Conclusion 2: A 2x3 within-subjects factorial ANOVA was calculated comparing the percentage of activity in the rectus abdominus during 3 Yoga poses on two different surfaces. The main effect for surface for the external oblique was not significant ( $F(1,16)=.001, p=.977$ ). The main effect for pose for the external oblique was not significant ( $F(2,32)=1.787, p=.184$ ). The interaction between surface and pose for the external oblique was also not significant ( $F(2,32)=2.008, p=.151$ ).

Hypothesis 3: There will be an increase in EMG activity of the erector spinae for all 3 Yoga poses under

the unstable condition when compared to the stable condition.

**Table 3.** Mean Normalized Peak EMG Activation for Erector Spinae during Yoga Poses and Different Surfaces

	Mean Peak EMG (SD)	
	Stable	Unstable
Tree	135% (138.8)	123% (115.0)
Boat	150% (192.1)	172% (255.6)
Side Plank	152% (171.3)	156% (189.6)

Conclusion 3: The main effect for surface for the erector spinae was not significant ( $F(1,16)=.923$ ,  $p=.351$ ). The main effect for pose for the erector spinae was not significant ( $F(2,32)=.823$ ,  $p=.448$ ). The interaction for the erector spinae was also not significant ( $F(2,32)=1.409$ ,  $p=.259$ ).



## DISCUSSION

The best clinicians match exercises to the abilities and goals of their patients. Yoga is a type of exercise not often chosen by athletic trainers but previous research shows that it may be a viable choice for the practicing athletic trainer. This section will examine Yoga as an exercise modality for athletic trainers in light of the results found in this study. The following section is divided into three subsections: Discussion of Results, Conclusions, and Recommendations.

### Discussion of Results

The goal of this study was to examine the peak EMG activity of the rectus abdominus, external oblique, and erector spinae during static Yoga poses on stable and unstable surfaces. Yoga has the benefit of reducing stress and potentially recruiting more muscle fibers because of the balance required to maintain each pose.<sup>3-7</sup> This has the potential to increase muscular strength in the targeted muscle. Previous research has determined that when the body is subjected to unstable conditions, such as a foam

surface, compared to stable surfaces, the central nervous system will recruit more muscle fibers in order to help the body maintain balance.<sup>3</sup> No studies have examined the combined effect on Yoga and surface condition on muscle activation.

Yoga can potentially stimulate muscle activity in the equivalence of a standard abdominal crunch exercise.<sup>16</sup> Yoga also tends to be less stressful on the joints and capable of being completed by any age group as opposed to other exercises which can cause a higher amount of stress to the joints such as running. This makes it a valuable tool for the athletic trainer, especially when working with patients that cannot perform high impact or high intensity exercises. An analysis of the completed study assisted in revealing why the results of this study may have occurred.

Previous studies examining muscle activity during exercises on stable and unstable surfaces found muscle activity to significantly increase on the unstable in comparison to the stable surface.<sup>8-12</sup> Other studies found no significant difference in muscle activity during exercise on either stable or unstable surface.<sup>13,14</sup> Due to these conflicting results, the present study was performed.

The present study determined that all three Yoga poses (Tree, Boat and Sid Plank) were effective in activating the

target muscles at a high level. The study did not find any effect of stability condition on muscle activation. This was different compared to previous studies for several reasons. Potential contributing factors in this difference include, the type of subjects, the utilization of Yoga poses as opposed to traditional exercises, and the EMG equipment used to measure electrical activity

During this study, there were no significant findings in muscle activity increasing in the individual core muscles during surface instability. During subject recruitment, the examiner only focused on subjects who were physically active. Previous studies recruited subjects familiar with the designated exercise.<sup>8-10,12,13</sup> For the present study, there was no consideration concerning the type of exercise the subjects completed, therefore all but one of the subjects was a novice to Yoga. Subjects completing weight training compared to subjects running for thirty minutes strengthens different muscles and provides a difference in skill level making even the easiest of the Yoga poses a challenge to hold. With these potential differences, the examined muscles in the core may or may not contract more or less because of the difference in exercise protocol. These differences can lead to a variation of electrical activity and skewed data. In a

more trained subject population, the stability condition would have been more likely to show an effect measurable by EMG.

The Yoga poses selected by the examiner were based on perception of difficulty ranging from least difficult to more difficult and consisted of the Tree pose, Boat pose, and Side Plank pose. Each Yoga pose was selected based on the pose's capability of targeting at least one of the three examined core muscles. The Tree pose was selected on the assumption it would target the erector spinae. The Boat pose and Side Plank pose were presumed to target the rectus abdominus and external oblique respectively. Most of the subjects, because of their unfamiliarity with Yoga, had to be shown the pose and given proper instruction on how to achieve the poses. Depending on the order chosen by the subject via counterbalanced random assignment, the subjects would then progress to complete the assigned pose on the stable or unstable surface. In most cases, performing any type of exercise on an unstable surface will increase the amount of muscular activity because of the unstable conditions but sometimes that is not always the case.<sup>8-12</sup> Depending on the exercises and surface changes, there may be no increases in activity.<sup>13,14</sup>

The examiner did not have the resources to obtain the same EMG equipment used in previous studies. The examiner used an MP150 Biopac with wired telemetry and surface electrodes for the study. The electrode placement was directly over the muscle belly with a ground wire placed below the Anterior Inferior Iliac Spine (ASIS). The ground wire was placed in order to reduce the amount of unnecessary electrical activity interfering with results. Despite these precautions, electrical activity from muscles not targeted by the examiner, such as the internal oblique and potentially the transversus abdominus, had the potential to interfere with the electrical activity of the examined core muscles during the study. The interference possibly caused a large increase in muscle activity in the external oblique, erector spinae and rectus abdominus. The potential interference allowed for the peak EMG of each muscle on both surfaces to exceed each muscle's maximal volitional contraction. This increased activation of surrounding muscles could mask increased activation in the targeted muscles brought about by the unstable condition.

The electrical activity in the rectus abdominus, external oblique, and erector spinae on BOSU ball and foam surface in this study was not significantly different. There also was no difference in muscular activity during

each selected pose. However, this study did not find Yoga to be a completely useless tool. A study performed by Petrofsky found Yoga has the ability to activate muscle activity in the same sense as standard core exercises.<sup>16</sup> In the present study the same conclusion can be made for all three Yoga poses. The results showed Yoga does possess the ability to target the muscles' maximal volitional contraction when performing any of the selected Yoga poses on either stable or unstable surface. The results show despite surface and pose selection, Yoga has the potential of being effective when striving to strengthen the core muscles. Regardless of the selection of poses or what type of surface Yoga is performed on, the core muscles will not increase in electrical activity more than if the poses were performed on an unstable surface.

Yoga uses the subject's own weight as a means to strengthen the athlete. This makes Yoga very cost effective, user friendly, and challenging for patients at a variety of fitness levels. Athletic trainers interested in attempting to strengthen athletes' core via Yoga poses do not have to focus primarily on pose selection. However, Athletic Trainers should be aware of the type of physical activity completed by athletes. This is important because Yoga potentially affects the core muscles differently based

on previous strengthening exercises. There is a variety of poses to select from with Yoga and any athletic trainer does not have to be restricted to certain poses because Yoga poses targeted towards the core muscles tend to activate the maximum muscle activity. Yoga can also be used in the clinical setting not only as because it cost effective and a stress reliever but also because it has the capability of strengthening the intended muscles.

### Conclusions

This study showed Yoga can be an effective tool to use by any person seeking a less stressful way to strengthen the rectus abdominus, the external oblique, and the erector spinae in the body. These findings did not show any difference due to pose selection, surface change, and muscle activation of the core but it did show an overall increase in activity in all muscles tested. Therefore, it can be concluded that Yoga is an effective exercise tool that can be used by anyone. It would be beneficial for subjects looking to practice Yoga, to have some knowledge of pose and proper technique in order to adequately strengthen the core muscles.

Despite the lack of any significant data in regards to surface, muscle activity, and pose, Yoga has shown it has the capabilities of activating the core muscles. This allows for athletic trainers and any other health care professionals to use Yoga as a strengthening tool. Yoga is a simple and cost effective way to provide diversity to strengthening protocols without excluding the young, the adolescent, the adult or the elderly.

#### Recommendations

While the majority of the subjects understood the tasks assigned to them, they were unfamiliar with the concept of Yoga. Many of the subjects were unaware of the technique and proper form required when performing Yoga. During the exercises, subjects had a tendency to break the static Yoga position by lowering the legs or arms or shifting places trying to maintain balance. This resulted in fluctuations of the electrical activity in the muscles being measured which lead to the data results being less consistent than when subjects accurately performed the exercises. It is recommended that future studies recruit subjects experienced in the practice of Yoga.



Two unstable surfaces were chosen by the examiner in order in order to ensure the completion of the poses. However, the examiner also did not want to choose a unstable surface that would be too difficult to complete by the subjects. The subjects had to be able to perform and hold the poses for fifteen seconds. However, the surfaces could not be too simple in fear of little to no increase in muscle activity. For future studies, it is recommended having each subject perform a pre-trial to examine his or her balance capabilities in an effort to have a more appropriate level of challenge.

The three Yoga poses chosen for the study were assumed to target the core from prior experience. Further research on Yoga poses and the actual muscle targets of those poses should be initiated in order to accurately target the proper muscles. In addition, before the actual data collection, the subjects were required to perform three manual muscle tests in order to compare the data results with the subject's maximal volitional contraction. Some subjects performed a standard abdominal crunch with arms crossed over their chest or arms crossed behind their head. Some subjects would have their knees flexed and others would have their legs extended. There was an inconsistent performance of the manual muscle testing. For future

studies, it is recommended the examiner establish a specific protocol for manual muscle testing for all the subjects.

## REFERENCES

1. Stevens V, Bouche K, Mahieu N, Coorevits P, Vanderstraeten G, Danneels L. Trunk Muscle Activity in Healthy Subjects during Bridging Stabilization Exercises. *BMC Musculoskeletal Disorders*. 2006;7:75.
2. Huang Q, Hodges P, Thorstensson. Postural Control of the Trunk in Response to Lateral Support Surface Translations during Trunk Movement and Loading. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2001;141(4):552-559.
3. Clark MA, Lurett SC. *NASM's Essentials of Sports Performance Training*. Baltimore, MD. Lippincott Williams & Wilkins; 2010: 171-190.
4. Carpenter M, Tokuno C, Thorstensson A, Cresswell A. Differential Control of Abdominal Muscles during Multi-Directional Support Surface Translation in Man. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2008;188(3):445-455.
5. Stevens V, Vleeming A, Bouche K, Mahieu N, Vanderstraeten G, Danneels L. Electromyographic Activity of Trunk and Hip Muscles during Stabilization Exercises in Four-Point Kneeling in Healthy Volunteers. *European Spine Journal: Official Publication Of The European Spine Society, The European Spinal Deformity Society, And The European Section Of The Cervical Spine Research Society*. 2007;16(5):711-718.
6. Alejandro Chaoul M, Cohen L. Rethinking Yoga and the Application of Yoga in Modern Medicine. *Cross Currents* [serial online]. June 2010;60(2):144-167. Available from: Academic Search Complete, Ipswich, MA. Accessed September 9, 2010
7. Prentice W. *Arheim's Principles of Athletic Training: A Competency-Based Approach*. New York, NY. McGraw-Hill; 2006: 101.

8. Norwood J, GS Anderson, M Gaetz, and P Twist. Electromyographic Activity of the Trunk Stabilizers during Stable and Unstable bench Press. *J. Strength Cond. Res.* 2007; 21(2): 497-502.
9. Monfort-Pañego M, Vera-García F, Sánchez-Zuriaga D, Sarti-Martínez M. Electromyographic Studies in Abdominal Exercises: A Literature Review, *Journal Of Manipulative And Physiological Therapeutics.* 2009;32(3):232-244.
10. Marshall P, Murphy B. Increased Deltoid and Abdominal Muscle Activity During Swiss Ball Bench Press. *Journal Of Strength And Conditioning Research / National Strength & Conditioning Association.* 2006;20(4):745-750.
11. Slijper H, Latash M. The Effects of Instability and Additional Hand Support on Anticipatory Postural Adjustments in Leg, Trunk, and Arm Muscles during Standing. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale.* 2000;135(1):81-93.
12. Petrofsky JS, Batt J, Davis N. Core Muscle Activity during Exercise on a Mini Stability Ball Compared with Abdominal Crunches on the Floor and on a Swiss Ball. *The Journal of Applied Research.* 2007;7(3) 255-272.
13. Willardson J, Fontana F, Bressel E. Effect of Surface Stability on Core Muscle Activity for Dynamic Resistance Exercises. *Intl J Sports Phys Performance.* 2009;4(1):97-109.
14. Illyés A, Kiss R. Electromyographic Analysis in Patients with Multidirectional Shoulder Instability During Pull, Forward Punch, Elevation and Overhead Throw. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal Of The ESSKA.* 2007;15(5):624-631.
15. Moreside J, Vera-Garcia F, McGill S. Trunk Muscle Activation Patterns, Lumbar Compressive Forces, and Spine Stability When Using the Bodyblade. *Physical Therapy.* 2007;87(2):153-163.

16. Petrofsky JS, Cuneo M, Dial R, Morris A. Muscle Activity during Yoga Breathing Exercise Compared to Abdominal Crunches. *J Applied Res.* 2005;5(3):501-507.

## APPENDICES

## APPENDIX A

## Review of Literature

## REVIEW OF LITERATURE

Electromyography is a technique that is used to measure the electrical activity in muscles during concentric, eccentric, and isometric activity. It can be used by applying adhesive pads to the very center of the muscle to predict maximum contraction.

EMG techniques allow researchers to determine the muscles that are contracting during certain exercises and the relative strength of these contractions.<sup>1</sup> Yoga is an exercise that requires minimum movement, depending on the level of experience and whether or not it is static or dynamic. Regardless, in Yoga, the subject to maintain certain poses, some more difficult than others, allowing for the subject to strengthen his or her muscles. In most of all the Yoga poses, it is required to contract the core muscles to maintain proper balance and breathing. In sports, the core can be a main contributor in every movement an athlete performs. EMG can be utilized to evaluate the muscle activation during various exercises.<sup>2</sup> Many researchers have looked at EMG activity during bench press or typical abdominal crunches but none have analyzed static yoga poses.<sup>3,4</sup>



The purpose of this Review of Literature is to enlighten the reader on previous work examining electromyography and variation in surfaces and their ability to affect EMG. The review of literature includes the following sections: Electromyography, Yoga, Stabilization and Research Progress, Core Stabilization Techniques and Exercises. The literature review will end with a summary of the research performed to date.

### Electromyography

Electromyography is a commonly used device for detecting and measuring muscular activity. This tool can be of great help in evaluating the effectiveness of various exercises in activating target muscles. It can also be used as a learning tool for athletes exhibiting a deficiency in muscular strength. In turn, the athlete can monitor his or her progression through the rehabilitation process by comparing before and after scores. This section will examine some examples of how EMG can best be utilized to evaluate muscle function. Best practices will take variables like skin moisture, surface contours and skin type into account when using surface electrodes.

Roy et al examined the performance of surface EMG sensors, different conditions and the affect of detecting

stability between sensor and the skin. Twenty-four subjects were used, twelve males and twelve females. The researcher used different detection surface contours and also adhesives when examining electrical contact with the skin. The skin for both studies examined dry and wet skin. Double-sided tape and increased surface contour increased the disruption in electrical activity. The application of hydrophilic gel provided greater movement especially on the subjects with moist skin. In general, when applying electrodes to the skin, precise cleaning and sufficient adhesive measures are necessary for a more accurate electrical reading.<sup>1</sup>

Jaggi et al also assessed surface and the effects on EMG reading. Jaggi et al also examined fine wire electromyography. Eleven female participants were used for this study. Self adhesive surface electrodes were placed over certain muscles and asked to participate in certain movements. The dual needle technique was performed after a twenty minute rest period. This study showed that surface EMG can assist in the classification of shoulder instability based on abnormal muscle patterns.<sup>2</sup>

There are different Electromyography devices and sensors that can be used but knowing how to use them properly is the key to receiving the best results in an

experiment. One experiment examined the subjects' skin type and found that different surfaces have to be taken into consideration because it may lead to a better or inaccurate reading.<sup>1</sup> Another study also researched surface contour and the effects on electrical detection. The researchers also tested whether or not EMG could be used for the detection of shoulder instability and the results showed that it was possible.

Electromyography is a useful tool to use but knowing how to accurately use EMG will allow for the researcher to obtain the best possible results. It has been shown that EMG has the possibility to analyze shoulder instability in addition to muscle activity. Measuring the electrical activity of muscles during Yoga poses should also be a possibility.

### Yoga

Yoga has been a practice that has been utilized for many years in multiple countries. The United States is finding Yoga to be a popular and successful way to exercise without stressing the body's joints. Yoga can be an alternative for those who are not as young and physically active. Yoga poses can also be modified to make Yoga more complex. For example, changing static poses and adding

dynamic movement to the Yoga positions. Many researchers theorize that Yoga assist in maintaining certain diseases such as cancer.<sup>3</sup> However, from previous experience, mostly every Yoga pose requires the practitioner to activate his or her core muscles.

Yoga can be categorized as either a mind-body technique (meditation) or actual movement and active participation (Yoga).<sup>3</sup> Yoga requires the body to maintain core contracture throughout the entire pose in most positions which makes Yoga a very useful exercise in sports. Petrofsky et al performed a study that analyzed muscle contracture of the right and left rectus abdominis as well as the right and left external oblique. Twenty-nine subjects 14 male and 15 females were used for the study. Muscle activity was monitored during deep breathing exercised in a seated position. The muscle activity for deep breathing equaled the muscle activity in abdominal crunches. Yoga can be assumed to be just as effective at strengthening the muscles as standard abdominal crunches.<sup>4</sup>

The proper technique of Yoga consist of maintain proper form, while taking deep, steady breathes.<sup>5</sup> When done correctly, Yoga releases endorphins that help sooth away stress.<sup>5</sup> Yoga is also a practice in which stabilization and balance are important components.

### Stabilization Research and Progress

Stabilization is a technique that may assist the athletes in strengthening their muscles based the level of muscle fibers recruited.<sup>6</sup> When introducing an unstable perturbation or surface to the end of an athlete's joint, more muscle fibers are recruited because it takes more strength from the athlete to provide balance and stability. The core is a main component that participates in most physical activity. For example, when walking the core muscles contract to maintain a proper center of gravity. If the core muscles can be strengthened through stabilization exercises then the athletes can gain more strength for future exercises.

Current research has shown most exercises, when introduced to some issue of stability, allow for electromyography of the muscles to increase. Norwood et al investigated instability training and the muscle recruitment of the core during dynamic multijoint movement. Subjects included 10 male and 5 female elite conditioning coaches and/or personal trainers with an average of 8.4 years of experience. A repeated-measures analysis of variance and a paired t-test. Six muscles were examined and four exercises were used to test the six muscles. The

muscles examined for this study were the latissimus dorsi, rectus abdominus, internal oblique, erector spinae, biceps femoris and soleus. The four exercises consisted of the bench press but on four different surfaces: stable bench press, upper-body instability on a stability ball, lower body on BOSU ball, and dual instability consistent of the stability ball for upper-body and BOSU ball for lower body. EMG recorded activity levels for five seconds. The study showed significant increases in EMG activity with increasing instability.<sup>7</sup> There was an additional study that researched muscles in the core and their activity during unstable conditions.

Marshall et al also did a similar study involving the deltoid and abdominal muscles and a swiss ball for instability. The study was conducted to investigate muscle activity of the upper body and abdominal muscles during concentric and eccentric contraction on and off a swiss ball. Deltoid and abdominal muscle activity increased with repetitions on the swiss ball. Deltoid activity increases when introduced to instability. Increased abdominal activity was not hypothesized but is presumed to be true with anecdotal reasoning.<sup>8</sup> Another researcher examined the core muscles but examined muscle activity during standing.

Slijper et al performed a study to examine the trunk muscle activation during standing. The study included muscles involved in total body stabilization: soleus, tibialis anterior, rectus abdominus, rectus femoris, biceps femoris, erector spinae, biceps brachii, triceps brachii, flexor carpi radialis and the extensor carpi ulnaris. Subjects performed ante-flexion movements in one shoulder while standing on a stable platform or on unstable board. Eight healthy subjects, six males and two females, were used for this experiment. Changes in background activity and displacements of center of pressure were quantified in time intervals. Leg and trunk muscles showed a significant drop but the arm muscles showed no significant change. The change was visible in both surface types.<sup>9</sup> Another study analyzed previous studies all targeting the abdominal muscle activity during stabilization conditions and found similar results.

Monfort-Pañego et al focused on many previous electromyography experiments and compiled the research articles on the EMG activity of the abdominal muscles together for a large literature review. Since this was a literature review, there were multiple male and female subjects within different age ranges. The researchers used the MEDLINE and Sport discus databases to locate the

articles. Eighty-seven studies were included in the literature review. There were studies that found significance in the increase of the abdominal muscle activity during the stabilization exercises. Other studies found no significant difference in muscle activity based on surface.<sup>10</sup> The results varied in both directions so another study was conducted which had better results.

Stevens et al studied abdominal muscle activity levels during bridging stabilization exercises. Thirty healthy university students and the subjects were fifteen male and fifteen females. The surface EMG activity was evaluated on both sides of the rectus abdominis. The muscle activity altered depending on the task or exercise administered. All back muscles assist in spinal positioning and movement.<sup>11</sup> Stevens et al also performed another study examining the trunk and hip muscles and their importance in spinal stabilization.

Stevens et al also studied EMG activity of trunk and hip muscles during three four-point kneeling stabilization exercises. Thirty healthy volunteers, fifteen men and fifteen females, were used. The highest muscle activity was found in the ipsilateral lumbar multifidus and gluteus maximus. The lowest muscle activity was found in the rectus abdominis and ipsilateral internal oblique. All muscles



function together to stabilize the spine.<sup>12</sup> Another researcher focused on surface stability instead of muscle stabilization.

Willardson et al researched surface stability and its correlation to muscle activation and found different results. Willardson et al focused on examining core muscle activity on stable ground and on an unstable surface (BOSU Balance Trainer). Twelve trained men volunteered for this study. Four exercises were used to examine the muscle activity. Five muscles were examined (the main core muscles). The subjects were given the specific exercise and were instructed to do the exercises at 50 % intensity on stable and unstable surfaces. Then, the subject had to perform the exercises at 75% intensity also on a stable surface. There seemed to be no difference in muscle activation in core muscles regardless of surface.<sup>13</sup>

While Willardson et al studied the five main core muscles of the abdomen, Carpenter et al focused on four abdominal muscles. Carpenter et al focused on how abdominal muscles were coordinated with the activation of muscles when introduced to unpredictable support surface. Twelve male subjects with a range of the same general age was utilized for the study. EMG data was recorded from the right rectus abdominis, obliquus externus, obliquus

internus, and transversus abdominis. The participants were to maintain their standing balance during forty support surface translations. The rectus abdominis and obliquus externus has earlier EMG onsets. The results provide evidence on how the abdominal muscles contribute to postural reactions.<sup>14</sup>

There was another study that was conducted on the shoulder that received similar results. Illyés and Kiss assessed muscle activity in multidirectional shoulder instability. Fifteen subjects with multidirectional shoulder instability were tested and the subjects were instructed to perform four different tasks. Eight different muscles were monitored. The time difference between the peaks of normalized voluntary electrical activity is greater than in the shoulders without instability.<sup>15</sup>

Hanada et al trunk muscle activation in older adults with trunk stabilization was conducted. Twelve asymptomatic adults with age ranges of 65 to 75 years were used for this study. The subjects were instructed to perform maximal voluntary isometric contractions for the EMG normalization purposes. Abdominal Muscle activation was seen and was more potent than the typical muscle contracture seen in the younger population.<sup>16</sup>

### Muscles Included in the Core

There are multiple muscles located in the body. Out of those muscles, there are certain muscles that work synergistically together to meet a certain muscle action. The muscles also work together as stabilizers. They function together to stabilize the spine and even assist in maintaining posture during walking.<sup>11-12,17</sup> If these muscles do not work together then there is a possibility of the athlete losing some strength when trying to complete a specific action or it may be done improperly. The abdomen consist of about five key muscles that work together to help with trunk movement and for added stability in the trunk.

There are about five main muscles that researchers analyze when looking at core strength or core stability. Four muscles can be located in the anterior view of the body and those muscles are the Rectus Abdominis, Transversus oblique, internal and external obliques. These muscles mainly contribute to active flexion, Rectus Abdominus, and rotational movement, the obliques. The last muscle included in the core is the Erector Spinae. The muscle is located posterior and elongates the entire spine. This muscle's main function is to provide back extension

and also to provide stability to the core as it works synergistically with the rest of the abdominal muscles.

### Core Stabilization Techniques and Exercises

There are multiple exercises that target the core muscles that athletic trainers use in rehabilitation programs. Knowing what exercises target what specific muscles and knowing what instability changes could be made to those exercises could allow for a more optimal strengthening of the core muscles in athletes. Some exercises focus on crunches which only work the muscles in one plane of motion while other exercises require more neuromuscular control and focuses on being multi-plane. Strengthening the core muscles will not only allow the athlete to get stronger but it also has the possibility of providing better posture support, preventing low back pain, and generally providing better athletic performance.

Parfrey et al examined abdominal muscle activation with variation in trunk flexion positions. EMG data was collected from the abdominal muscles, external oblique, lower abdominal stabilizers, rectus femoris and biceps femoris. Fourteen males were used for this study. The variation contained three different variables. There was no difference between the bent knee and extended leg sit up

positions. The bent knee sit up position produced higher muscle activity in the lower abdominal stabilizers and the rectus femoris.<sup>17</sup> Bird et al focused away from stabilization and more so on better ways to strengthen the abdominal muscles.

Bird et al examined the difference in the abdominal muscle activity in the AB-slide and the abdominal crunch. Forty five subjects, thirty females and fifteen males, volunteered for this study. The subjects performed five exercise trials with the EMG attached to the upper rectus abdominis, external oblique, and lower rectus abdominis. During concentric movement, the external oblique and lower rectus abdominus had high muscle activation. During eccentric contractions, the rectus abdominis and external oblique had higher muscle activity in the AB-slide.<sup>18</sup>

Escamillia et al also researched alternatives to help strengthen the abdominal muscles rather than the traditional abdominal crunch. Escamillia et al studied the muscle activity between nontraditional sit-up and traditional crunches with electromyography. Twenty-one healthy men and women whose ages ranged between 23 and 43 years recruited for this study. There were nine men and five females with at least six months of resistance training. Anterior and Posterior EMG muscle activity were the highest with the

nontraditional abdominal exercises. Lumbar paraspinal muscle EMG activity was low for both exercises. Non-traditional abdominal exercises were more successful in muscle activation and extraneous abdominal exercises.<sup>19</sup> Petrofsky et al also researched more efficient ways to strengthen the abdominal muscles instead of standard crunches.

Petrofsky et al examined the muscle use during core body exercise using a mini stability ball compared with abdominal crunches. Three male and seven female subjects were used with an age range of eighteen and thirty-five. The EMG recorded above the abdominals and the low back muscles. Three levels of core exercises were tested. It showed that the mini ball required 50 % more muscle activity in comparison to standard crunches.<sup>20</sup>

Moreside et al also found similar results when introducing the athlete to an exercise that focuses on stabilization and perturbations. Moreside et al analyzed trunk muscle activation patterns, spin kinematics, and lumbar compressive forces that occur when using the Bodyblade®. Fourteen healthy male subjects volunteered for the study. The electromyography was placed on the trunk and shoulder. With the utilization of the Bodyblade®, the greatest muscle activation was located in the internal and

external oblique muscles. The Bodyblade® can enhance or compromise the spine stability.<sup>21</sup>

Huang et al found similar results pertaining to a possible compromise in spine stability when introduced to perturbations. Huang et al examined possible performance changes in posture due to translations. Eight normally active males were used for this experiment. The researchers added perturbations to test that hypothesis. The patients were translated left and right randomly and also given certain task. When the perturbation was applied, decreased efficiency in posture was identified.<sup>22</sup>

### Results/Findings

There has been a large amount of research that examines the electrical activity of the core muscles. Even more so, most researchers compare and analyze the scores by using different surfaces. This is important because if the subject can receive a more active participation of muscles simply by inducing unstable surface change then that should be included in every muscle training program. It is also an easy alternative to increase muscle activity.

Marshall and Murphy examined the differences in electromyographic activity in prime movers and the abdominal muscle, while performing certain exercises, were

studied. Eight healthy subjects, eight male and four females were used for this study. There was no difference between muscle activity and surface for squats. However, activity level of the triceps and abdominal was the highest when performing push-ups on the Swiss Ball increases muscle activity during exercises where the surface is unstable.<sup>23</sup>

Fransson et al analyzed vision and its capability to have an effect on balance on foam surface. Eight healthy subjects were used, eight males and four females. EMG activity was monitored in the tibialis anterior and gastrocnemius. The subjects repeated the trials with open and closed eyes allowing the examiner to verify the effect of vision on movement. Linear knee and hip movement increased while on the foam. Vision stabilized shoulder and head movement more than knee and hip on the foam surface. Vision decreased tibialis anterior muscle activity on foam surface.<sup>24</sup>

Imai et al focused on trying to determine whether trunk activity changes with a change in surface. Nine healthy males were used for this study and they have to have a generally same body mass. The EMG measured the muscle activity of the core and back muscles. Five exercises were performed on stable and unstable surfaces. With the elbow-toe exercises all muscles increased activity



on an unstable surface. The hand-knee and side bridge exercises had an increase in activity of the more global muscles on an unstable surface. The Curl-up exercise increased the activity of the external obliques but decreased the activity of the transversus abdominis on the unstable surface.<sup>25</sup>

Gatti et al analyzed the activation muscles used to keep one leg raised from a supine position in healthy and Multiple Sclerosis subjects. Fourteen healthy subjects, with ages ranging from twenty eight to fifty six years were utilized for this study. Greater activation of the biceps femoris than abdominal muscles was located in the healthy subjects for the A condition. The B condition had a decrease between the two muscles. In the Multiple Sclerosis patients, there was no difference with either condition. In Multiple Sclerosis patients, there is an alteration in stabilization muscles.<sup>26</sup>

### Summary

The literature review detailed previous studies' research of muscle activity during exercise. It is important to find alternative methods to help strengthen the core muscles. The core serves as a stabilizer,

assistance in gait, and also a key contributor to strength.<sup>2,11,12,17</sup> Research varied in terms of findings regarding muscle activity when having the subjects balance on a stable surface then compare the numbers to the unstable surface. Others found there to be a significant difference in the EMG activity occurring in certain muscles on the unstable surface in comparison to the stable surface. While some researchers focused on the surface stability and its correlation to EMG activity, others focused more on the surface conductivity of the electrodes and the effects of different surfaces may have on EMG reading. When doing the EMG reading, most of the examiners monitored the five major muscles included in the core. Out of the five muscles of the core, the rectus abdominus was included in every study while other studies did not examine all core muscles. When examining the muscles there were multiple exercises utilized for the experiments to test the different muscles. Every study had some EMG experiment that distinguishes which muscles react the most to certain increases in stress. However, none of the studies focused on Yoga and its potential for supplying an alternative way in strengthening muscles. The exercises most studies focused on were primarily abdominal crunches, bench press, sit-ups and bridging exercises.<sup>7-8,10-12,17-20,23</sup>

## References

1. Roy S, De Luca G, Cheng M, Johansson A, Gilmore L, De Luca C. Electro-mechanical Stability of Surface EMG Sensors. *Med Biol Eng Compt.* 2007;45(5):447-457.
2. Jaggi A, Malone A, Cowan J, Lambert S, Bayley I, Cairns M. Prospective Blinded Comparison of Surface versus Wire Electromyographic Analysis of Muscle Recruitment in Shoulder Instability. *Physiotherapy Res Intl: J Res Clinicians Phys Ther.* 2009;14(1):17-29.
3. Alejandro Chaoul M, Cohen L. Rethinking Yoga and the Application of Yoga in Modern Medicine. *Cross Currents* [serial online]. June 2010;60(2):144-167. Available from: Academic Search Complete, Ipswich, MA. Accessed September 9, 2010
4. Petrofsky JS, Cuneo M, Dial R, Morris A. Muscle Activity during Yoga Breathing Exercise Compared to Abdominal Crunches. *J Applied Res.* 2005;5(3):501-507.
5. Prentice W. Arheim's Principles of Athletic Training: A Competency-Based Approach. New York, NY. McGraw-Hill; 2006: 101.
6. Clark MA, Lurett SC. NASM's Essentials of Sports Performance Training. Baltimore, MD. Lippincott Williams & Wilkins; 2010: 171-190.
7. Norwood, J., G.S. Anderson, M. Gaetz, and P. Twist. Electromyographic Activity of the Trunk Stabilizers during Stable and Unstable bench Press. *J Strength Cond Res.* 2007; 21(2)
8. Marshall P, Murphy B. Increased Deltoid and Abdominal Muscle Activity during Swiss Ball Bench Press. *J Strength Cond Res / Natl Strength Cond Assoc.* 2006;20(4):745-750.
9. Slijper H, Latash M. The Effects of Instability and Additional Hand Support on Anticipatory Postural Adjustments in Leg, Trunk, and Arm Muscles during Standing. *Exp Brain Res. Experimentelle Hirnforschung. Expérimentation Cérébrale.* 2000;135(1):81-93.

10. Monfort-Pañego M, Vera-García F, Sánchez-Zuriaga D, Sarti-Martínez M. Electromyographic Studies in Abdominal Exercises: A Literature Review, *J Manip Physiol Ther.* 2009;32(3):232-244.
11. Stevens V, Bouche K, Mahieu N, Coorevits P, Vanderstraeten G, Danneels L. Trunk Muscle Activity in Healthy Subjects during Bridging Stabilization Exercises. *BMC Musculoskeletal Disorders.* 2006;7:75.
12. Stevens V, Vleeming A, Bouche K, Mahieu N, Vanderstraeten G, Danneels L. Electromyographic Activity of Trunk and Hip Muscles during Stabilization Exercises in Four-Point Kneeling in Healthy Volunteers. *European Spine Journal: Official Publication Of The European Spine Society, The European Spinal Deformity Society, And The European Section Of The Cervical Spine Research Society.* 2007;16(5):711-718.
13. Willardson J, Fontana F, Bressel E. Effect of Surface Stability on Core Muscle Activity for Dynamic Resistance Exercises. *Intl J Sports Phys Performance.* 2009;4(1):97-109.
14. Carpenter M, Tokuno C, Thorstensson A, Cresswell A. Differential Control of Abdominal Muscles during Multi-Directional Support Surface Translation in Man. *Exp Brain Res. Experimentelle Hirnforschung. Expérimentation Cérébrale.* 2008;188(3):445-455.
15. Illyés A, Kiss R. Electromyographic analysis in Patients with Multidirectional Shoulder Instability during pull, forward punch, elevation and overhead throw. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal Of The ESSKA.* 2007;15(5):624-631.
16. Hanada E, Hubley-Kozey C, McKeon M, Gordon S. The Feasibility of Measuring the Activation of the Trunk Muscles in Healthy Older Adults during Trunk Stability Exercises. *BMC Geriatrics.* 2008;8:33.
17. Parfrey K, Docherty D, Workman R, Behm D. The Effects of Different Sit- and Curl-up Postures on Activation of Abdominal and Hip Flexor Musculature. *Applied Physiology, Nutrition, And Metabolism = Physiologie*

- Appliquée, Nutrition Et Métabolisme*. 2008;33(5):888-895.
18. Bird M, Fletcher K, Koch A . Electromyographic Comparison of the AB-Slide and Crunch Exercises. *J Strength Cond Res / Natl Strength Cond Assoc*. 2006;20(2):436-440.
  19. Escamilla R, Babb E, DeWitt R, et al. Electromyographic Analysis of Traditional and Nontraditional Abdominal Exercises: Implications for Rehabilitation and Training. *Phys Ther*. 2006;86(5):656-671.
  20. Petrofsky JS, Batt J, Davis N Core Muscle Activity during Exercise on a Mini Stability Ball Compared with Abdominal Crunches on the Floor and on a Swiss Ball. *J Appl Res*. 2007;7(3) 255-272.
  21. Moreside J, Vera-Garcia F, McGill S. Trunk Muscle Activation Patterns, Lumbar Compressive Forces, and Spine Stability When Using the Bodyblade. *Phys Ther*. 2007;87(2):153-163
  22. Huang Q, Hodges P, Thorstensson. Postural Control of the Trunk in Response to Lateral Support Surface Translations during Trunk Movement and Loading. *Exp Brain Res. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2001;141(4):552-559.
  23. Marshall P, Murphy B. Changes in Muscle Activity and Perceived Exertions during Exercises Performed on a Swiss Ball. *Applied Physiology, Nutrition, And Metabolism = Physiologie Appliquée, Nutrition Et Métabolisme*. 2006;31(4):376-383.
  24. Fransson P, Gomez S, Patel M, Johansson L. Changes in the Multi-Segmented Body Movements and EMG Activity While Standing on Firm and Foam Support Surfaces. *European Journal Of Applied Physiology*. 2007;101(1):81-89
  25. Imai A, Kaneoka K, Okubo Y, et al. Trunk Muscles Activity during Lumbar Stabilization Exercises on Both a Stable and Unstable Surface. *J Orthop Sports Phys*. 2010;40(6):369-375.

26. Gatti R, Corti M, Govetto S, Bonzani K, Boccardi S. Electromyographic Activity to Keep a Lower Limb in a Raised Position in Healthy Subjects and Subjects with Multiple Sclerosis. *Multiple Sclerosis (Houndmills, Basingstoke, England)*. 2008;14(5):691-693.

## APPENDIX B

## The Problem

## THE PROBLEM

### Statement of the Problem

There has been a generous amount of research conducted that utilizes electromyography to evaluate muscle function and also research has been found focusing on the correlation of unstable surfaces and their affect on certain muscles. During these experiments, the researchers have been testing common exercises such as the chest press or the push up.

In addition, there has been basic research on the benefits of Yoga. Research in Yoga has previously been performed and has found that Yoga is a healthy alternative of exercise for not only the elderly but also individuals who do not want to perform high impact exercises (i.e. running).<sup>3</sup> Yoga is becoming a popular exercise among the young and the elderly. A minimal amount of research has been initiated evaluating any EMG activity during Yoga poses.

Yoga can be changed and altered based on an athlete's needs. Yoga also consists of multiple levels starting from beginners and ending with expert. Yoga can be altered to make the poses more dynamic in comparison to having static



poses. Yoga could be targeted toward a physical therapy clinic and it could be applied in the athletic setting for most ages. It has also been implied that Yoga has the potential of decreasing psychological stress via endorphin release during deep, controlled breathing.<sup>3,5</sup>

Therefore, the purpose of the study is to examine EMG activity in the core muscle during static yoga poses on stable and unstable surfaces. The inclusion of the core muscles is important because Yoga has a tendency to include poses that require multi-joint activity targeting the core along with various other muscles. Using unstable and stable surfaces allow the researcher to verify if the muscles increase in activity during surface changes.

#### Definition of Terms

The following terms will be defined for this study:

- 1) Balance - the ability to maintain an equal distribution of weight
- 2) Vrksasana - a yoga pose called the "tree pose"
- 3) Paripurna Navasana - a yoga pose called the "boat pose"
- 4) Vasisthasa - a yoga pose called the "side plank"
- 5) Physically active - an individual who has been doing some form of cardiorespiratory exercise that raises

their heart rate to their target heart rate zone and maintains that condition for a minimum of 30 minutes at least 3 out of the 7 days of the week.

- 6) Perturbations - the causation of disturbance of the state of equilibrium.

#### Basic Assumptions

The following are basic assumptions of this study:

- 1) The subjects will utilize their maximum effort to maintain the poses.
- 2) The subjects will maintain the proper form after examiner shows subjects proper Yoga technique.
- 3) The EMG equipment will be properly calibrated, accurate and reliable during testing.
- 4) The subjects accurately assess their physical activity levels.

#### Limitations of the Study

The following are possible limitations of the study:

- 1) Only physically active subjects were utilized.
- 2) The EMG machine can only measure superficial muscles such as the rectus abdominus, external oblique and erector spinae

- 3) EMG signals have the potential to include signal from unwanted muscles in the area of the target muscle.
- 4) Subjects will have varying levels of knowledge about Yoga.
- 5) There was only a small sample sized used.

#### Delimitations of the Study

The following are possible delimitations of the study:

- 1) The examiner chose three Yoga poses that had the possibility of lacking in difficulty so that subjects were capable of performing regardless of their fitness levels.
- 2) EMG activity will only be measured in four muscles.

#### Significance of the Study

The study showed what muscles in the core, if any, increase in activity when being subjected to instability. The study had the potential of allowing three new exercises, targeting the core, to be utilized in the clinical setting. The three Yoga exercises chosen for the study were only a minuscule amount compared to the various range of exercises. There were also Yoga poses that targeted different muscle groups based on anecdotal reasoning.

Yoga potentially allowed for the athletic trainers and any other health care professional looking to utilize Yoga as a strengthening tool, to have a variety of strengthening exercises. The exercises showed no significant increase in muscle activity when introduced to instability compared to a stable surface. Although there the study showed no significant increase, there was evidence that Yoga provided an alternative way of strengthening the core. The muscle activity during the three Yoga poses reached 100% of the muscles' maximal voluntary contraction.

Yoga is also a cost effective way to strengthen muscles compared to exercise equipment. Therefore, if an athletic trainer works in a setting that contains little to no equipment, he or she can have the athletes strengthen their muscles through Yoga. In addition, Yoga potentially targets the cardiovascular system by adding dynamic movement. Athletic Trainers and health care professionals can strengthen muscles while improving an athlete's cardiovascular fitness. The time spent working with an athlete when targeting those categories separately can be reduced by doing Yoga exercises. Yoga also requires the athlete to have fine balance skills which is critical in most sports. Yoga not only can strengthen the core, it has the potential of being more cost effective than machinery,

targets the cardiovascular system and helps athletes improve balance and coordination.

Yoga can possibly be utilized by ATCs and other health care professionals as an additional "tool" in their "toolbox" to strengthen the core. However, ATCs and health care professionals need to be aware of the potential differences in muscle activity based on previous physical activity. The muscle activity could potentially increase significantly in a subject that runs for exercise. Subjects who practice weight lifting may potentially have little to no increase in muscle activity during Yoga. In addition, muscle activity can appear sporadic based on subject experience and knowledge of Yoga.

Athletic trainers have an abundance of exercise equipment and exercises to choose from when creating exercise programs. The three Yoga poses could potentially be included in these wide ranges of choices. With the possible addition of the three Yoga poses, athletic trainers could provide a variety in an exercise program. In turn, the athlete could be further challenged with Yoga. Despite the lack of significance in the study, Yoga has the potential of opening a new door in providing new ways to strengthen the core in the physically active population.

## APPENDIX C

## Additional Methods

## APPENDIX C1

Institutional Review Board -  
California University of Pennsylvania



California University of Pennsylvania

Proposal Number  
10-033  
Date Received  
03-18-2011

PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

*Project Title* EMG of the Core Muscles during Static Yoga Poses on Stable and Unstable Surfaces

*Researcher/Project Director* Elizabeth Banks

*Phone #* 804-896-0262      *E-mail Address* ban4961@calu.edu

*Faculty Sponsor (if required)* Thomas F. West

*Department* Health Science

*Project Dates* March 18, 2011 to March 17, 2012

*Sponsoring Agent (if applicable)* \_\_\_\_\_

*Project to be Conducted at* California University of Pennsylvania

*Project Purpose:*     *Thesis*     *Research*     *Class Project*     *Other*

**Keep a copy of this form for your records.**



**Please attach a typed, detailed summary of your project AND complete items 2 through 6.**

1. *Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(es) or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.*

The primary purpose of this study is to examine EMG activity of various muscles during static Yoga poses on stable and unstable surfaces. The subjects will be 25 physically active male and female college students from California University of Pennsylvania. Physically active is defined by the examiner as exercise that increases heart rate performed at least three times a week for a minimum of thirty minutes per bout. Individuals who do not exercise at the minimum requirement were not chosen for this study. In addition, the subjects cannot have an inner ear infection, vertigo, stability issues, weak joints that pose instability problems or any balance problems. Any subjects that have the mentioned conditions were not chosen for the study.

There will be a test trial conducted before the actual experiment occurs. The recruitment of subjects will consist of announcements made health science courses. Subjects interested in participating in the study will have the opportunity to sign a sign in sheet distributed by the examiner during the announcement. The subjects volunteering for the experiment will be given the informed consent form and instructions that describe the experiment and the procedures needed to complete the exercises. After the subjects read the instructions, they will have a chance to ask questions or if the subjects choose not to participate, they will have that opportunity to discontinue participation. There will be a 5 minute warm-up consistent of biking on an elliptical for two minutes to warm the muscles. A metronome will be used to ensure that all participants experience the same warm-up protocol. Following the 2 minute warm-up, the students will perform three various Yoga steps called Sun Salutations. In order to ensure all subjects do not spend more or less time in one pose than the other, a stop watch will be used to time 10 seconds between each pose. Once the warm-up is completed, the subjects will proceed to select which poses to complete first on a stable and unstable surface. This will be done by doing a counterbalanced random assignment where the examiner will separate the order of poses starting from beginner, intermediate, and expert until there will be six possible choices. Once the order is selected, the subjects will begin to do 1 of 3 poses: the Tree pose (beginner), Side Plank (intermediate), and Boat pose (Expert). Then the examiner will place the surface EMG electrodes over the muscle belly of the Rectus Abdominis, the External Oblique, and the Erector Spinae. With the electrodes in place, the subjects will be instructed to start in the corresponding beginning phase then progress to the proper end phase of the exercise and hold that pose for 15 seconds. As previously done for the warm-up, a stop watch will be utilized to ensure all subjects spend equal time between poses. As the subject maintains the Yoga pose, the examiner will document the peak activity of each muscle on both surfaces on all three trials. There will be a demographic sheet used to document the numbers of the peak EMG activity and also the sheet should document which order the student did the Yoga poses. Each beginning phase will vary based on the different Yoga pose. The subjects will do each pose on a stable surface first then proceed to the unstable surface which will be performed on a foam pad or BOSU ball depending on difficulty level. The same protocol is used for the unstable surface. Each subject will be given a maximum of 3 re-trials if he or she fails to fully hold or complete the pose for the 15 seconds. If the subjects do not fully complete the pose out of the 3 re-trials, the best peak EMG score will be utilized. The subjects will be given a 30 second rest period between each pose. The subjects will then do the second assigned pose, then the third assigned pose on both stable and unstable surfaces. Once the subjects have completed the first trial run, there will be two extra trial runs conducted. During, the second and third trial run, the exact same procedures should be followed. Once all three trials are completed and documented, the subjects will be recommended to do a 5 minute cool down that consist of stretching the lower and upper extremity on his or her own time to minimize the chance of muscle soreness. After the experiment is completed, the subjects are free to leave.

2. *Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.*

3

- a. *How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.*

There are minimal risks to the participants, primarily the risk of falling and a musculoskeletal injury. These risks are minimized to a great extent by only including healthy, physically active college age students. In the event of an injury, an athletic trainer will be in the same room as the participant during exercises to administer care and possibly refer for additional care, if necessary. Subjects with balance disorders will be screened by the researcher via the informed consent and discussion and will be excluded from the study. Specifically the subject will indicate if they have balance problems, vertigo, ankle instability, inner ear problems, or take any medications that have the potential of decreasing balance, increasing dizziness or impairing vision. Any subjects indicating yes will be excluded. To minimize musculoskeletal injury risk, the participants will be instructed to stop participation if discomfort beyond that normally associated with exercise occurs. If any female participant become pregnant during the study, the participant is notified that she has the choice to continue or discontinue her participation without penalty.

- b. *How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.*

The selection of subjects will be chosen according to responses on the first come first serve basis. An email to the entire campus broadcasting the time, place, subject requirement, the benefits or the study, and the subjects will be notified that the study involves research. All subjects will have equal opportunity to volunteer by responding to the prior email. If some subjects do not volunteer and respond to the email then those subjects will not be considered for the experiment. There will be no indication that any money or compensation will be gained from this study. The subjects will also be encouraged to not feel pressured to participate. It is also discouraged for any faculty member to potential issue extra credit for participation. It is stressed that all subjects should volunteer only for the reason of wanting to participate.

- c. *How will you obtain informed consent from each participant or the subject's legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.*

The chosen subjects will be given an informed consent form that indicates the protocol the subjects need to follow, what the experiment consist of, any foreseeable risk, any potential benefits of the experiment prior to beginning the experiment, and the purpose of the study. If the subject, for any reason, does not sign the informed consent or feels as though he or she does not want to participate in the study then he or she will not be included in the study. The signed informed consent forms will be stored in the athletic training program director's office under lock and key in a cabinet that only the program director has a key to. The informed consent forms will be keep in a folder not visible by anyone.

- d. *Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects' responses and provisions for maintaining the security and confidentiality of the data.*

Once the data is fully collected, the data will be stored in the athletic training program director's office under lock and key. Subjects will only be identified by subject number. Electronic data files will be password protected. Only the program has the key to the cabinet and office allowing for the information to remain safe.

3. Check the appropriate box(es) that describe the subjects you plan to use.

<input checked="" type="checkbox"/> Adult volunteers	<input type="checkbox"/> Mentally Disabled People
<input checked="" type="checkbox"/> CAL University Students	<input type="checkbox"/> Economically Disadvantaged People
<input type="checkbox"/> Other Students	<input type="checkbox"/> Educationally Disadvantaged People
<input type="checkbox"/> Prisoners	<input type="checkbox"/> Fetuses or fetal material
<input type="checkbox"/> Pregnant Women	<input type="checkbox"/> Children Under 18
<input type="checkbox"/> Physically Handicapped People	<input type="checkbox"/> Neonates

4. Is remuneration involved in your project?  Yes or  No. If yes, Explain here.

5. Is this project part of a grant?  Yes or  No If yes, provide the following information:

Title of the Grant Proposal \_\_\_\_\_

Name of the Funding Agency \_\_\_\_\_

Dates of the Project Period \_\_\_\_\_

6. Does your project involve the debriefing of those who participated?  Yes or  No

If Yes, explain the debriefing process here.

7. If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix \_\_\_ in the Policies and Procedures Manual.

**California University of Pennsylvania Institutional Review Board**  
**Survey/Interview/Questionnaire Consent Checklist** (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview or questionnaire?

**YES**—Complete this form

**NO**—You MUST complete the “Informed Consent Checklist”—skip the remainder of this form

Does your survey/interview/questionnaire cover letter or explanatory statement include:

- (1) Statement about the general nature of the survey and how the data will be used?
- (2) Statement as to who the primary researcher is, including name, phone, and email address?
- (3) FOR ALL STUDENTS: Is the faculty advisor’s name and contact information provided?
- (4) Statement that participation is voluntary?
- (5) Statement that participation may be discontinued at any time without penalty and all data discarded?
- (6) Statement that the results are confidential?
- (7) Statement that results are anonymous?
- (8) Statement as to level of risk anticipated or that minimal risk is anticipated? (NOTE: If more than minimal risk is anticipated, a full consent form is required—and the Informed Consent Checklist must be completed)
- (9) Statement that returning the survey is an indication of consent to use the data?
- (10) Who to contact regarding the project and how to contact this person?
- (11) Statement as to where the results will be housed and how maintained? (unless otherwise approved by the IRB, must be a secure location on University premises)
- (12) Is there text equivalent to: “Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm”? (the actual dates will be specified in the approval notice from the IRB)?
- (13) FOR ELECTRONIC/WEBSITE SURVEYS: Does the text of the cover letter or explanatory statement appear before any data is requested from the participant?
- (14) FOR ELECTONIC/WEBSITE SURVEYS: Can the participant discontinue participation at any point in the process and all data is immediately discarded?

**California University of Pennsylvania Institutional Review Board  
Informed Consent Checklist (v021209)**

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview, or questionnaire?

**YES**—DO NOT complete this form. You MUST complete the “Survey/Interview/Questionnaire Consent Checklist” instead.

**NO**—Complete the remainder of this form.

**1. Introduction** (check each)

- (1.1) Is there a statement that the study involves research?
- (1.2) Is there an explanation of the purpose of the research?

**2. Is the participant.** (check each)

- (2.1) Given an invitation to participate?
- (2.2) Told why he/she was selected.
- (2.3) Told the expected duration of the participation.
- (2.4) Informed that participation is voluntary?
- (2.5) Informed that all records are confidential?
- (2.6) Told that he/she may withdraw from the research at any time without penalty or loss of benefits?
- (2.7) 18 years of age or older? (if not, see Section #9, Special Considerations below)

**3. Procedures** (check each).

- (3.1) Are the procedures identified and explained?
- (3.2) Are the procedures that are being investigated clearly identified?
- (3.3) Are treatment conditions identified?

**4. Risks and discomforts.** (check each)

- (4.1) Are foreseeable risks or discomforts identified?
- (4.2) Is the likelihood of any risks or discomforts identified?
- (4.3) Is there a description of the steps that will be taken to minimize any risks or discomforts?
- (4.4) Is there an acknowledgement of potentially unforeseeable risks?
- (4.5) Is the participant informed about what treatment or follow up courses of action are available should there be some physical, emotional, or psychological harm?
- (4.6) Is there a description of the benefits, if any, to the participant or to others that may be reasonably expected from the research and an estimate of the likelihood of these benefits?
- (4.7) Is there a disclosure of any appropriate alternative procedures or courses of treatment that might be advantageous to the participant?

**5. Records and documentation.** (check each)

- (5.1) Is there a statement describing how records will be kept confidential?
- (5.2) Is there a statement as to where the records will be kept and that this is a secure location?
- (5.3) Is there a statement as to who will have access to the records?

**6. For research involving more than minimal risk** (check each),

- (6.1) Is there an explanation and description of any compensation and other medical or counseling treatments that are available if the participants are injured through participation?
- (6.2) Is there a statement where further information can be obtained regarding the treatments?
- (6.3) Is there information regarding who to contact in the event of research-related injury?

**7. Contacts** (check each)

- (7.1) Is the participant given a list of contacts for answers to questions about the research and the participant's rights?
- (7.2) Is the principal researcher identified with name and phone number and email address?
- (7.3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

**8. General Considerations** (check each)

- (8.1) Is there a statement indicating that the participant is making a decision whether or not to participate, and that his/her signature indicates that he/she has decided to participate having read and discussed the information in the informed consent?
- (8.2) Are all technical terms fully explained to the participant?
- (8.3) Is the informed consent written at a level that the participant can understand?
- (8.4) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)

**9. Specific Considerations** (check as appropriate)

- (9.1) If the participant is or may become pregnant is there a statement that the particular treatment or procedure may involve risks, foreseeable or currently unforeseeable, to the participant or to the embryo or fetus?
- (9.2) Is there a statement specifying the circumstances in which the participation may be terminated by the investigator without the participant's consent?
- (9.3) Are any costs to the participant clearly spelled out?
- (9.4) If the participant desires to withdraw from the research, are procedures for orderly termination spelled out?
- (9.5) Is there a statement that the Principal Investigator will inform the participant or any significant new findings developed during the research that may affect them and influence their willingness to continue participation?
- (9.6) Is the participant is less than 18 years of age? If so, a parent or guardian must sign the consent form and assent must be obtained from the child
  - Is the consent form written in such a manner that it is clear that the parent/guardian is giving permission for their child to participate?
  - Is a child assent form being used?
  - Does the assent form (if used) clearly indicate that the child can freely refuse to participate or discontinue participation at any time without penalty or coercion?
- (9.7) Are all consent and assent forms written at a level that the intended participant can understand? (generally, 8<sup>th</sup> grade level for adults, age-appropriate for children)

**California University of Pennsylvania Institutional Review Board**  
**Review Request Checklist** (v021209)

This form **MUST** accompany all IRB review requests.  
 Unless otherwise specified, **ALL** items must be present in your review request.

Have you:

- (1.0) FOR ALL STUDIES: Completed ALL items on the Review Request Form?
- Pay particular attention to:
  - (1.1) Names and email addresses of all investigators
    - (1.1.1) FOR ALL STUDENTS: use only your CalU email address
    - (1.1.2) FOR ALL STUDENTS: Name and email address of your faculty research advisor
  - (1.2) Project dates (must be in the future—no studies will be approved which have already begun or scheduled to begin before final IRB approval—**NO EXCEPTIONS**)
  - (1.3) Answered completely and in detail, the questions in items 2a through 2d?
    - 2a: NOTE: No studies can have zero risk, the lowest risk is “minimal risk”. If more than minimal risk is involved you **MUST**:
      - i. Delineate all anticipated risks in detail;
      - ii. Explain in detail how these risks will be minimized;
      - iii. Detail the procedures for dealing with adverse outcomes due to these risks.
      - iv. Cite peer reviewed references in support of your explanation.
    - 2b. Complete all items.
    - 2c. Describe informed consent procedures in detail.
    - 2d. NOTE: to maintain security and confidentiality of data, all study records must be housed in a secure (locked) location **ON UNIVERSITY PREMISES**. The actual location (department, office, etc.) must be specified in your explanation and be listed on any consent forms or cover letters.
  - (1.4) Checked all appropriate boxes in Section 3? If participants under the age of 18 years are to be included (regardless of what the study involves) you **MUST**:
    - (1.4.1) Obtain informed consent from the parent or guardian—consent forms must be written so that it is clear that the parent/guardian is giving permission for their child to participate.
    - (1.4.2) Document how you will obtain assent from the child—This must be done in an age-appropriate manner. Regardless of whether the parent/guardian has given permission, a child is completely free to refuse to participate, so the investigator must document how the child indicated agreement to participate (“assent”).
  - (1.5) Included all grant information in section 5?
  - (1.6) Included ALL signatures?
- (2.0) FOR STUDIES INVOLVING MORE THAN JUST SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:
  - (2.1) Attached a copy of all consent form(s)?
  - (2.2) FOR STUDIES INVOLVING INDIVIDUALS LESS THAN 18 YEARS OF AGE: attached a copy of all assent forms (if such a form is used)?
  - (2.3) Completed and attached a copy of the Consent Form Checklist? (as appropriate—see that checklist for instructions)

- (3.0) FOR STUDIES INVOLVING ONLY SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:
- (3.1) Attached a copy of the cover letter/information sheet?
  - (3.2) Completed and attached a copy of the Survey/Interview/Questionnaire Consent Checklist? (see that checklist for instructions)
  - (3.3) Attached a copy of the actual survey, interview, or questionnaire questions in their final form?
- (4.0) FOR ALL STUDENTS: Has your faculty research advisor:
- (4.1) Thoroughly reviewed and approved your study?
  - (4.2) Thoroughly reviewed and approved your IRB paperwork? including:
    - (4.2.1) Review request form,
    - (4.2.2) All consent forms, (if used)
    - (4.2.3) All assent forms (if used)
    - (4.2.4) All Survey/Interview/Questionnaire cover letters (if used)
    - (4.2.5) All checklists
  - (4.3) IMPORTANT NOTE: Your advisor's signature on the review request form indicates that they have thoroughly reviewed your proposal and verified that it meets all IRB and University requirements.
- (5.0) Have you retained a copy of all submitted documentation for your records?



**Project Director's Certification**  
Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

**Professional Research**

\_\_\_\_\_  
Project Director's Signature

\_\_\_\_\_  
Department Chairperson's Signature

**Student or Class Research**

*Elizabeth G. Gabe*  
\_\_\_\_\_  
Student Researcher's Signature

*Thomas J. J.*  
\_\_\_\_\_  
Supervising Faculty Member's  
Signature if required

*Thomas J. J.*  
\_\_\_\_\_  
Department Chairperson's Signature

**ACTION OF REVIEW BOARD** (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

Approved [ \_\_\_\_\_ ]

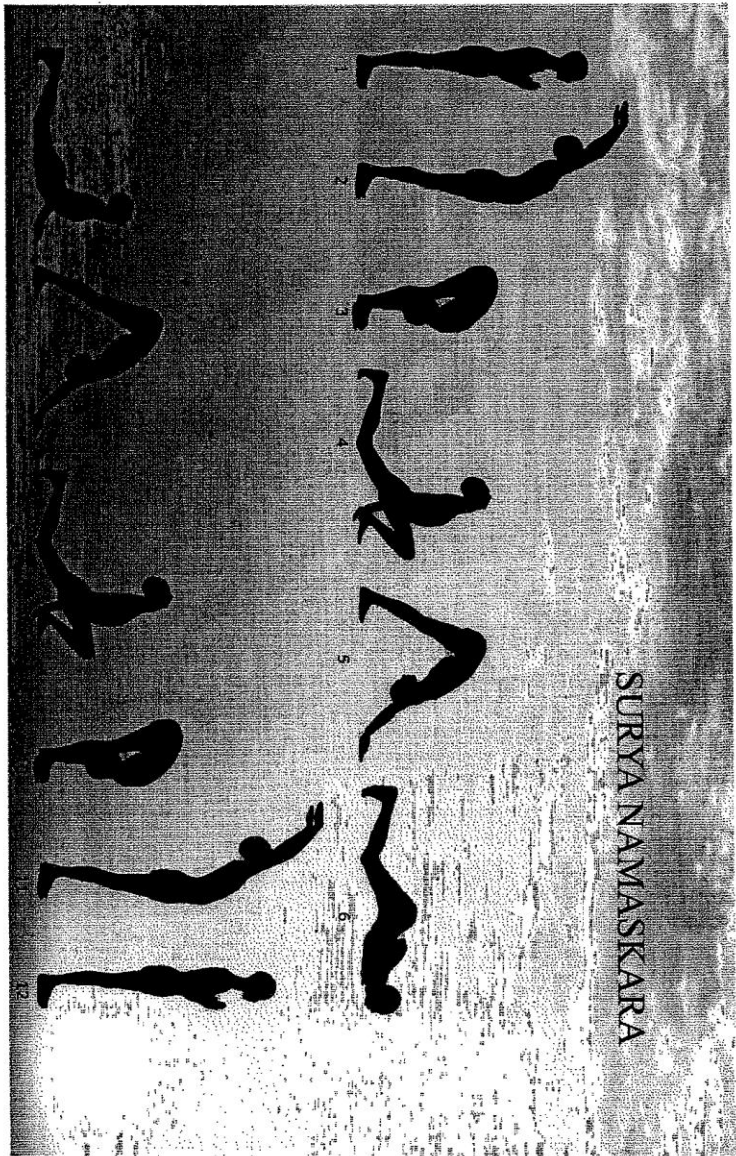
Disapproved

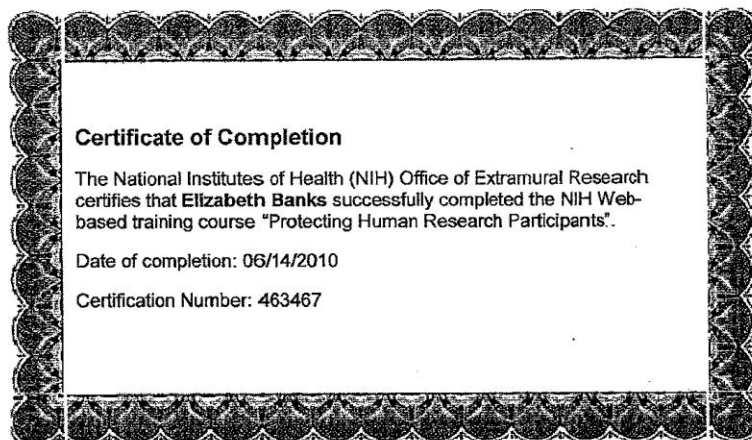
\_\_\_\_\_  
Chairperson, Institutional Review Board

\_\_\_\_\_  
Date

Approved, September 12, 2005 / (updated 02-09-09)

Sun Salutations Step By Step





Institutional Review Board  
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Robert Skwarecki, Ph.D., CCC-SLP, Chair

**Ms. Banks**

Please consider this email as official notification that your proposal titled "EMG of the Core Muscles during Static Yoga Poses on Stable and Unstable Surfaces" (Proposal #10-033) has been approved by the California University of Pennsylvania Institutional Review Board as amended.

The effective date of the approval is 03-18-2011 and the expiration date is 03-17-2012. These dates must appear on the consent form.

Please note that Federal Policy requires that you notify the IRB promptly regarding any of the following:

- (1) Any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented)
- (2) Any events that affect the safety or well-being of subjects
- (3) Any modifications of your study or other responses that are necessitated by any events reported in (2).
- (4) To continue your research beyond the approval expiration date of 03-17-2012 you must file additional information to be considered for continuing review. Please contact [instreviewboard@calu.edu](mailto:instreviewboard@calu.edu)  
Please notify the Board when data collection is complete.

Regards,

Robert Skwarecki, Ph.D., CCC-SLP  
Chair, Institutional Review Board

APPENDIX C2

Informed Consent Form



## California University of Pennsylvania

### Informed Consent Form

1. Elizabeth Banks, who is a Graduate Athletic Training Student at California University of Pennsylvania, has requested my participation in a research study at California University of Pennsylvania. The title of the research is EMG OF THE CORE MUSCLES DURING STATIC YOGA POSES ON STABLE AND UNSTABLE SURFACES.

2. I have been informed that the purpose of this study is to examine EMG activity of various muscles during static Yoga poses on stable and unstable surfaces. I understand that I must be 18 years of age or older to participate. I understand that I have been asked to participate since I perform steady exercises at least three times a week for at least thirty minutes. In addition, I understand subjects cannot have an inner ear infection, vertigo, stability issues, weak joints that pose instability problems or any balance problems.

3. I have been invited to participate in this research project. My participation is voluntary and I can choose to discontinue my participation at any time without penalty or loss of benefits. My participation will involve a 5 minute warm-up session and then participating in the 10 minute exercise program. I have been informed of the possible risks and benefits of my participation. Subjects have the option of resigning from the study without any repercussions.

The 5 minute warm-up session will require me to warm-up on an elliptical trainer for one minute to warm the muscles. Following the 1 minute warm-up, I will then perform three various Yoga steps called Sun Salutations. Then I will proceed to the 10 minute exercise protocol. Prior to beginning the protocol, the researcher will place adhesive electrodes on my skin, over the rectus abdominus, external abdominal oblique and erector spinae to measure the electrical activity during the yoga poses.

With the electrodes in place, I will be instructed to start performing yoga poses, holding the each of the 3 poses for 15 seconds. As I maintain each Yoga pose, the examiner will document the peak activity of each muscle as measured by the electrodes. I will perform each pose on a stable surface first then proceed to perform the same pose on an foam pad and or BOSU ball to create a less stable surface. I will be given a 30 second rest period between each pose. I will then do the second assigned pose, then the third assigned pose on both stable and unstable surfaces. This process will be repeated for 2 additional trials for a total of 9 poses being held. During the second and third trial run, the exact same procedures will be followed. Once all three trials are completed and documented, I will be recommended to do a 5 minute cool down that consist of stretching the lower and

upper extremity on my own time to minimize the chance of muscle soreness. After the experiment, I am free to leave.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. With participation in a research program such as this there is always the potential for unforeseeable risks as well.

Potential risks are loss of balance and the possibility of strains and sprains. In order to minimize these risks, the examiner trusts my word that I have no balance issues, vertigo, ankle instability, or that I do not take any medications that have the potential of decreasing balance, increasing dizziness or impairing vision. The researcher will be in close proximity during all performed exercises on both surfaces to limit the chances of a fall and to provide care should I become injured. If I become pregnant during the study, I understand that I have the choice to continue or discontinue my participation in the study at me and my child's discretion.

5. I understand that, in case of injury, I can expect to receive treatment or care in Hamer Hall's Athletic Training Facility. This treatment will be provided by the researcher, Elizabeth Banks, under the supervision of the CalU athletic training faculty, all of which can administer emergency care. Additional services needed for prolonged care will be referred to the attending staff at the Downey Garofola Health Services located on campus.

6. There are no feasible alternative procedures available for this study.

7. I understand that the possible benefits of my participation in the research is to help determine EMG activity in the core muscles during Yoga poses on stable and unstable surfaces. This study will provide athletic trainers and other health care professionals with other means to strengthen the core muscles and general physical fitness for the physically active and athletic population.

8. I understand that the results of the research study may be published but my name or identity will not be revealed. Only aggregate data will be reported. In order to maintain confidentiality of my records, Elizabeth Banks will maintain all documents in a secure location on campus and password protect all electronic files so that only the student researcher and research advisor can access the data. Each subject will be given a specific subject number to represent his or her name so as to protect the anonymity of each subject.

9. I have been informed that I will not be compensated for my participation.

10. I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by:

Elizabeth Banks  
STUDENT/PRIMARY RESEARCHER

Ban4961@calu.edu  
804-896-0262

Thomas F. West,  
RESEARCH ADVISOR  
West\_t.calu.edu  
724-938-5933

11. I understand that written responses may be used in quotations for publication but my identity will remain anonymous.

12. I have read the above information and am electing to participate in this study. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

13. This study has been approved by the California University of Pennsylvania Institutional Review Board.

14. The IRB approval dates for this project are from: 03/18/11 to 03/17/12.

Subject's  
signature: \_\_\_\_\_ Date: \_\_\_\_\_

Witness  
signature: \_\_\_\_\_ Date: \_\_\_\_\_



Appendix C3  
Demographic Information

## Demographic Information

Age: \_\_\_\_\_

Year/school: \_\_\_\_\_

Gender: male or female

Are you taking any medication: Yes or No

If yes, what are the side effects: \_\_\_\_\_

Do you have unstable or weak ankles? Yes or No

Do you have an inner ear problem? Yes or No

Do you experience vertigo? Yes or No

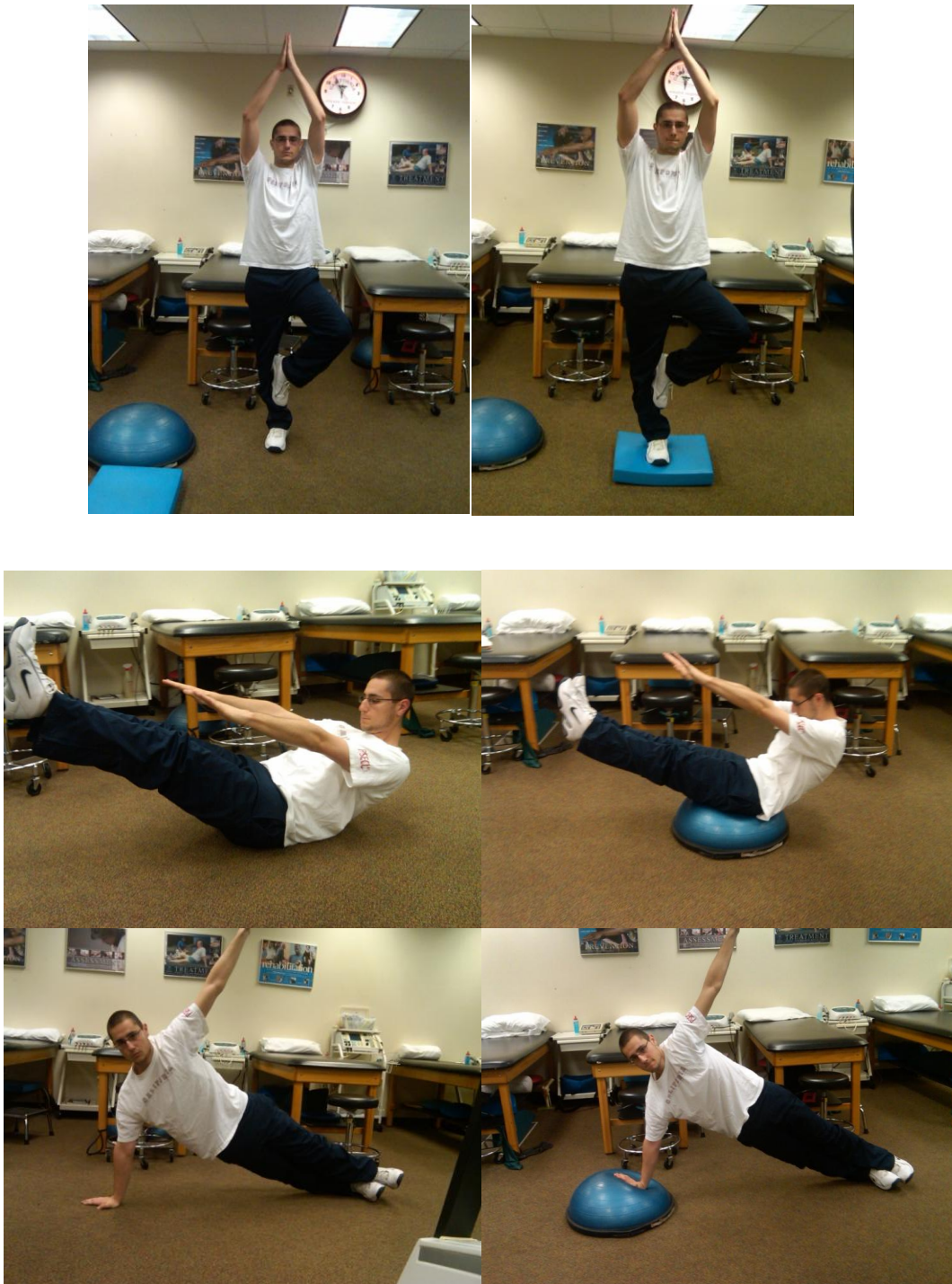
How many times do you exercise a week? How Long?

\_\_\_\_\_

Do you have any knowledge about Yoga? Yes or No

Appendix C4

Yoga Poses



**Figure 1.** Yoga Poses, Tree Pose, Boat Pose, Side Plank Pose, on stable and unstable conditions

**Photo/Audio Tape/Video Tape Release Form**

Project Title *EMG of the Core Muscles*  
Protocol Number: *10-033*  
Principle Investigator Name  
*during Static Yoga*  
*Poses on Stable*  
*and Unstable Surfaces*

Photo/Audio Tape/ Video Tape Release

We request the use of (photographic/audio/video) material as part of our study. We specifically ask your consent to use this material as we deem proper. The material will be used for the research project as we have described it in the informed consent document you have signed. These materials may be used for news releases, professional publications, professional conferences, websites, and pictorial exhibits related to our study.

We also emphasize that the appearance of these materials on certain media (websites, professional publications, news releases) may require the transfer of copyright of the images or audio materials. This means that other individuals may use your image or voice. Regarding the use of your likeness in photographs, tapes, or recordings, please check one of the following boxes:

I do...  
 I do not...

Give unconditional permission for the investigators to utilize photographs/recordings of me.

  
Signature

*5-4-11*  
Date

Note: Even should you choose not to allow your image to be used, we can still benefit from your inclusion as a research study participant.

## REFERENCES

1. Roy S, De Luca G, Cheng M, Johansson A, Gilmore L, De Luca C. Electromechanical Stability of Surface EMG Sensors. *Medical & Biological Engineering & Computing*. 2007;45(5):447-457.
2. Jaggi A, Malone A, Cowan J, Lambert S, Bayley I, Cairns M. Prospective Blinded Comparison of Surface versus Wire Electromyographic Analysis of Muscle Recruitment in Shoulder Instability. *Physiotherapy Research International: The Journal For Researchers And Clinicians In Physical Therapy*. 2009;14(1):17-29.
3. Alejandro Chaoul M, Cohen L. Rethinking Yoga and the Application of Yoga in Modern Medicine. *Cross Currents* [serial online]. June 2010;60(2):144-167. Available from: Academic Search Complete, Ipswich, MA. Accessed September 9, 2010
4. Prentice W. Arheim's Principles of Athletic Training: A Competency-Based Approach. New York, NY. McGraw-Hill; 2006: 101.
5. Clark MA, Lurett SC. NASM's Essentials of Sports Performance Training. Baltimore, MD. Lippincott Williams & Wilkens; 2010: 171-190.
6. Norwood, J, GS Anderson, M Gaetz, and P Twist. Electromyographic Activity of the Trunk Stabilizers during Stable and Unstable bench Press. *J. Strength Cond. Res*. 2007; 21(2)
7. Marshall P, Murphy B. Increased Deltoid and Abdominal Muscle Activity during Swiss Ball Bench Press. *Journal Of Strength And Conditioning Research / National Strength & Conditioning Association*. 2006;20(4):745-750.
8. Slijper H, Latash M. The Effects of Instability and Additional Hand Support on Anticipatory Postural

- Adjustments in Leg, Trunk, and Arm Muscles during Standing. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2000;135(1):81-93.
9. Monfort-Pañego M, Vera-García F, Sánchez-Zuriaga D, Sarti-Martínez M. Electromyographic Studies in Abdominal Exercises: A Literature Review, *Journal Of Manipulative And Physiological Therapeutics*. 2009;32(3):232-244.
  10. Stevens V, Bouche K, Mahieu N, Coorevits P, Vanderstraeten G, Danneels L. Trunk Muscle Activity in Healthy Subjects during Bridging Stabilization Exercises. *BMC Musculoskeletal Disorders*. 2006;7:75.
  11. Stevens V, Vleeming A, Bouche K, Mahieu N, Vanderstraeten G, Danneels L. Electromyographic Activity of Trunk and Hip Muscles during Stabilization Exercises in Four-Point Kneeling in Healthy Volunteers. *European Spine Journal: Official Publication Of The European Spine Society, The European Spinal Deformity Society, And The European Section Of The Cervical Spine Research Society*. 2007;16(5):711-718.
  12. Willardson J, Fontana F, Bressel E. Effect of Surface Stability on Core Muscle Activity for Dynamic Resistance Exercises. *Intl J Sports Phys Performance*. 2009;4(1):97-109.
  13. Carpenter M, Tokuno C, Thorstensson A, Cresswell A. Differential Control of Abdominal Muscles during Multi-Directional Support Surface Translation in Man. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2008;188(3):445-455.
  14. Illyés A, Kiss R. Electromyographic analysis in Patients with Multidirectional Shoulder Instability during pull, forward punch, elevation and overhead throw. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal Of The ESSKA*. 2007;15(5):624-631.
  15. Hanada E, Hubley-Kozey C, McKeon M, Gordon S. The Feasibility of Measuring the Activation of the Trunk

- Muscles in Healthy Older Adults during Trunk Stability Exercises. *BMC Geriatrics*.2008;8:33.
16. Parfrey K, Docherty D, Workman R, Behm D. The Effects of Different Sit- and Curl-up Postures on Activation of Abdominal and Hip Flexor Musculature. *Applied Physiology, Nutrition, And Metabolism = Physiologie Appliquée, Nutrition Et Métabolisme*. 2008;33(5):888-895.
  17. Bird M, Fletcher K, Koch A . Electromyographic Comparison of the AB-Slide and Crunch Exercises. *Journal Of Strength And Conditioning Research / National Strength & Conditioning Association*. 2006;20(2):436-440.
  18. Escamilla R, Babb E, DeWitt R, et al. Electromyographic Analysis of Traditional and Nontraditional Abdominal Exercises: Implications for Rehabilitation and Training. *Phys Ther*. 2006;86(5):656-671.
  19. Petrofsky JS, Batt J, Davis N Core Muscle Activity during Exercise on a Mini Stability Ball Compared with Abdominal Crunches on the Floor and on a Swiss Ball. *The Journal of Applied Research*. 2007;7(3) 255-272.
  20. Moreside J, Vera-Garcia F, McGill S. Trunk Muscle Activation Patterns, Lumbar Compressive Forces, and Spine Stability When Using the Bodyblade. *Physical Therapy*. 2007;87(2):153-163
  21. Huang Q, Hodges P, Thorstensson. Postural Control of the Trunk in Response to Lateral Support Surface Translations during Trunk Movement and Loading. *Experimental Brain Research. Experimentelle Hirnforschung. Expérimentation Cérébrale*. 2001;141(4):552-559.
  22. Marshall P, Murphy B. Changes in Muscle Activity and Perceived Exertions during Exercises Performed on a Swiss Ball. *Applied Physiology, Nutrition, And Metabolism = Physiologie Appliquée, Nutrition Et Métabolisme*. 2006;31(4):376-383.
  23. Fransson P, Gomez S, Patel M, Johansson L. Changes in the Multi-Segmented Body Movements and EMG Activity



While Standing on Firm and Foam Support Surfaces.  
*European Journal Of Applied Physiology*.  
2007;101(1):81-89

24. Imai A, Kaneoka K, Okubo Y, et al. Trunk Muscles Activity during Lumbar Stabilization Exercises on Both a Stable and Unstable Surface. *The Journal Of Orthopaedic And Sports Physical Therapy*. 2010;40(6):369-375.
25. Gatti R, Corti M, Govetto S, Bonzani K, Boccardi S. Electromyographic Activity to Keep a Lower Limb in a Raised Position in Healthy Subjects and Subjects with Multiple Sclerosis. *Multiple Sclerosis (Houndmills, Basingstoke, England)*. 2008;14(5):691-693.

## ABSTRACT

**Title:** Electromyographic Activity in Core Muscles During Static Yoga Poses Performed on Stable And Unstable Surfaces

**Researcher:** Elizabeth M. Banks, BS, PES

**Advisor:** Thomas F. West, PhD, ATC

**Type:** Thesis

**Context:** Yoga has become a popular form of exercise in the young and elderly. Yoga encompasses core strength which is beneficial for most sports and everyday activity. Yoga requires balance and stabilization which requires motor unit recruitment which increases strength. Despite these benefits, there has been minimum research on Yoga.

**Objective:** To determine if electromyographic activity in three core muscles increases during static Yoga poses on unstable surfaces than stable surfaces with  $p \leq 0.05$ .

**Design:** Quasi-experimental, within subjects, repeated measures design.

**Setting:** Controlled, laboratory setting.

**Patients or Other Participants:** Seventeen (5 males, 12 females) physically active, college aged participants with no history of an inner ear infection, vertigo, stability issues, and weak joints.

**Intervention:** Three Yoga poses by the examiner based on perceived difficulty (beginner, intermediate, expert). The pose and surface order were selected via counterbalanced random assignment. Poses were performed on solid ground, a BOSU ball, and a foam disk on the dominant side. Muscle activity was recorded via a MP150 amplifier with wired telemetry unit connected to a PC running Biopac Acknowledge 4.0 software. Muscle

activity was compared to the percentage of the maximal voluntary contraction (%MVC). The average of 2 trials for each completed pose and surface were used for analysis. SPSS version 18.0 for windows using a factorial repeated measures analysis of variance determined the significance of the muscle activity.

**Main Outcome Measures:**

Core muscle activity was compared to the respective MVC percentage.

**Results:**

The interaction between surface condition, pose and muscle was not significant ( $F(4,64)=.626$ ,  $p=.646$ ). The main effect for surface for the rectus abdominus, external oblique, and erector spinae were not significant respectively ( $F(1,16)=1.149$ ,  $p=.300$ ), ( $F(1,16)=.001$ ,  $p=.977$ ), ( $F(1,16)=.923$ ,  $p=.351$ ). The main effect for pose for the rectus abdominus, external oblique and erector spinae were not significant respectively ( $F(2,32)=1.879$ ,  $p=.169$ ), ( $F(2,32)=1.787$ ,  $p=.184$ ), ( $F(2,32)=.823$ ,  $p=.448$ ). The interaction between surface and pose was not significant for the rectus abdominus, external oblique, and erector spinae respectively ( $F(2,32)=2.018$ ,  $p=.150$ ), ( $F(2,32)=2.008$ ,  $p=.151$ ), ( $F(2,32)=1.409$ ,  $p=.259$ ). This indicated that pose, surface, and pose and surface had no effect on the muscle activity in any of the three muscles.

**Conclusions:**

Yoga has stress relieving benefits, is cost effective, low impact and can be practiced by any age group. Even without significant findings, Yoga is still an effective tool that can be used by Athletic Trainers and other health care professionals to help strengthen muscles. Yoga has the capability of activating one hundred percent of the core muscles maximal volitional contraction regardless of surface or pose difficulty.