AN ELECTROMYOGRAPHICAL ANALYSIS OF SHOULDER AND TRUNK MUSCLES DURING CHEST PRESS ON STABLE AND UNSTABLE PLATFORMS

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AN ELECTROMYOGRAPHICAL ANALYSIS OF SHOULDER AND TRUNK MUSCLES DURING CHEST PRESS ON STABLE AND UNSTABLE PLATFORMS

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ABSTRACT

AN ELECTROMYOGRAPHICAL ANALYSIS OF SHOULDER AND TRUNK MUSCLES DURING CHEST PRESS ON STABLE AND UNSTABLE PLATFORMS

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August 2013

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The use of unstable surfaces during resistance training has become increasingly popular. The majority of research examining the effect of replacing a bench with a stability ball during the supine chest press has found that force output capability is compromised without a subsequent decrease in agonist muscle activation. It has been hypothesized that this discrepancy is caused by a co-contraction mechanism at the glenohumeral joint, favoring joint stability over force production. The purpose of this study was to examine the effect of instability on agonist, antagonist, and core musculature during the supine chest press. Twenty-seven healthy male subjects performed isometric chest press at maximal voluntary contraction (MVC), 75% MVC, and 50% MVC while mean and peak electromyographic (EMG) output and mean force output of various muscles were measured. The unstable condition produced a significant decrease in MVC force output and agonist EMG activation at MVC and submaximal intensities. A significant increase in core activation was present on the stability ball during submaximal intensities. No significant changes were present in core EMG activation at MVC or antagonist EMG activation at MVC and submaximal intensities. The only exception was peak EMG activation of the infraspinatus, which showed a significant increase during 75% MVC trials on the stability ball. A significant co-contraction may not be present at the shoulder during the supine chest press, which was the primary hypothesis for the decrease in force output during unstable trials in previous studies. Further, using a stability ball in place of a stable bench during chest press may compromise strength gains expected during high-intensity resistance training without providing any additional benefit to the core musculature.

CHAPTER I

INTRODUCTION

In the past few decades, unstable exercise platforms have become an increasingly common part of resistance training workouts and sport performance regimens in fitness and health care settings (12, 29). Some of the proposed benefits of these tools are improved balance, increased proprioception, and greater recruitment of core muscles during exercise. However, the research that has been performed to date regarding the effects of instability during traditional resistance training exercises is clear in some areas, but inconsistent in others. It seems clear that unstable platforms cause a decrease in the force output that the musculoskeletal system as a whole can place on an external object (1, 3, 4, 7, 13, 15, 16, 21, 22, 24), but the reason why is not clear. Electromyographical (EMG) data have been inconsistent in methodology and unclear in results; some have shown no difference in muscle activity during stable and unstable exercise (1, 8, 18, 20, 24, 26, 28), some have shown a reduction in muscle activity during unstable exercise (2, 4, 13, 21, 22), and some have reported that instability causes an increase in muscle activation (3, 19, 23). The literature to date has not sufficiently explained the reason for this discrepancy. This investigation has been designed to study the EMG activation patterns of agonist, antagonist and core stabilizing muscle groups during isometric chest press exercise on a stable platform compared to an unstable platform.

Purpose of the Study

The purpose of this study was to compare the activity of shoulder and trunk muscles during isometric chest press exercise performed on stable and unstable platforms.

Hypothesis

The null hypothesis for this study was that there would be no differences in muscle activity between stable and unstable conditions.

The research hypothesis for this study was that the presence of an unstable platform would cause an increase in muscle activity for the posterior deltoid, infraspinatus, latissimus dorsi, trapezius, and transverse abdominis/internal oblique muscles, but no significant change in muscle activity for the pectoralis major or anterior deltoid.

Operational Definitions

1. Agonist – the muscle whose contraction causes skeletal displacement in the desired plane of motion.
2. Antagonist – the muscle whose contraction opposes the action of the agonist.
3. Unstable platforms – balance training platforms commonly used in resistance training and rehabilitation (Swiss ball, Dyna-Disc, BOSU ball).

Delimitations

This study was delimited to:

1. Recreational athletes with at least 1 year of resistance training experience and at least 6 months of unstable resistance training experience.

2. The chest press exercise performed on an exercise bench and stability ball.
3. Males age 18 to 35 years.

Limitations of the Study

1. The results of this study can only be applied to male recreational athletes age 18 to 35 years.
2. Electromyographical activity of the selected muscles was specific to the exercise studied and may not apply to other exercise positions or surface types.
3. Subjects were not randomly selected due to the limited number of qualifying subjects available.

Assumptions

The following assumptions were made in this investigation:

1. Each individual was free from use of any performance-enhancing or ergogenic aids before and during the research trials.
2. Each subject would report to the researcher any injuries that occur during the trial period.
3. Each subject would complete the required health questionnaire and Disability of the Arm, Shoulder, and Hand (DASH) functional assessment carefully and honestly.

Significance of the Study

The research that has been performed to date on the subject of unstable platforms has been inconclusive. The majority of research (1, 3, 4, 7, 13, 15, 16, 21, 22, 24) supports the loss of force output on an external object under unstable conditions. However, the data on agonist muscle activation varies between no change in activation between platforms (1, 8, 20, 24, 26, 28), a reduction in activation under unstable conditions (2, 4, 13, 21, 22), and an increase in muscle activation for unstable exercise (3, 19, 23).

Another challenge within the literature is that there is variability between the exercises that have been studied. For the purpose of this research, muscle activity during the chest press is in question. If there is truly a reduction in agonist muscle activation under unstable conditions, then the reason for the loss of force output is clear. However, if EMG readings for agonist muscles do not exhibit any change, then there must be another variable to explain the loss of force. The unique characteristic of this study is that it will investigate the effect of instability on antagonist and trunk stabilizing muscles during the chest press, as well as add further evidence toward determining the true muscle activation levels of the agonist muscle group.

These results are important in all athletic settings because resistance training on unstable platforms is a popular method of exercise which may provide alternative benefits for special groups. It is important to understand the full effect of this training modality so that the health and fitness professional can properly weigh the pros and cons of unstable exercise before applying it into an exercise protocol.

CHAPTER II

LITERATURE REVIEW

In the past few decades, a new fitness product has gained popularity among health and fitness professionals and recreational exercisers alike. Neuromuscular training platforms such as the Swiss ball, the Both-Sides-Up (BOSU) ball, and the DynaDisc can now be found in health clubs and weight training facilities all over the world. Only recently have researchers begun gathering data in an attempt to give a clear picture of the role of unstable platforms in resistance training among healthy individuals. Exercises performed on unstable platforms, when compared to stable platforms, consistently show lower force/power output measures, but data is not conclusive for measures of muscle activation.

Force / Power Output

Several research studies agree that the musculoskeletal system is unable to place as much force upon an external resistance when positioned on an unstable platform (1, 3, 4, 7, 13, 15, 16, 21, 22, 24). These studies have examined the force/power output generated when comparing identical exercises performed on stable and unstable platforms.

Decrease in Force/Power Output

The first attempt to analyze force output in this way was performed by Behm, Anderson, and Curnew (4) in 2002. Using a strain gauge and force plates, maximum voluntary contraction force (MVC) was measured isometrically during knee extension and plantarflexion while subjects were seated on a bench compared to a Swiss ball. Force levels were 70% lower in knee extension and 20% lower in plantarflexion. Two years later, Anderson and Behm (1) analyzed the effects of unstable platforms on the upper extremity. Using a customized strain gauge, they asked their subjects to perform an isometric chest press exercise while lying supine on a bench and on a Swiss ball. Maximum voluntary isometric force output was 59.6% lower when lying on the unstable platform. In 2006, McBride, Cormie, and Dean (21) measured isometric squat force output while standing on the floor and on inflated Dyna-Discs, maintaining a 100 degree knee joint angle. Peak force and rate of force development were both measured, and both were significantly lower on the unstable platform: 46% and 40%, respectively. The following year, Drinkwater, Pritchett and Behm (7) measured peak concentric power, force, velocity, and peak eccentric power in subjects performing 10RM squats while standing on a hard surface, Dyna-Discs, and BOSU balls. They reported that unstable platforms reduced all measures, although numerical data was not explicitly stated. In 2008, Koshida et al. (16) used an accelerometer to measure peak power, force and velocity during 50% 1RM supine barbell chest presses between platform types. Their results showed a significant decrease in all three measurements while lying on a Swiss ball. In 2010, McBride et al. (22) measured stable and unstable 1RM squat exercises and reported a 35% lower 1RM for unstable condition. The same year, Kohler, Flanagan, and

Whiting (13) measured 10RM in shoulder press exercises using stable and unstable loads (barbell vs. dumbbell) and stable and unstable platforms (bench vs. Swiss ball). Force output, as measured by 10RM, was an average of 10% lower while seated on the Swiss ball. Sparkes and Behm (24) investigated the training effect of instability over an 8-week training protocol comparing force output for platform type at both pre- and post-training. Their results showed that subjects were able to produce 42% more chest press force on a stable platform than an unstable platform, independent of training or time. In 2011, Araujo et al. (3) reported that instability decreased load values produced during one-arm push-up exercise on stable and unstable platforms. Many of these authors referenced Kornecki, Kebel, and Siemenski (15), who found in 2001 that the ability of the upper extremity to place force upon a pendular resistive apparatus decreased when the handle became increasingly unstable.

No Change in Force/Power Output

In 2008, Goodman et al. (8) reported no difference in 1RM measurements while performing Smith machine chest press exercises on a bench and a Swiss ball. They concluded that the inconsistent findings were a result of placing the Swiss ball in a position to support the subject's head, thus negating the "tonic neck reflex." It is also possible that the Smith machine reduced the level of instability present during the exercise in exchange for a lower risk of injury.

Muscle Activation

Another approach to understand the effects of an unstable surface on muscle activity is via surface electromyography (EMG). This method gives a generalized idea of the activity of superficial musculature. It also provides data that can help to determine possible reasons for the observed decrease in force/power output in exercises performed on unstable surfaces. However, the results of these studies are inconsistent. Some have reported that resistance training on unstable platforms causes a decrease in agonist EMG activity (2, 4, 13, 21, 22), others report no significant difference for platform type (1, 8, 20, 24, 26, 28), and some have reported that instability causes an increase in muscle activation (3, 19, 23). The inconsistency in these findings may be influenced by variations in experimental design, studying varying muscle groups, the type of exercise performed, or lack of sufficient statistical power associated with results. Additionally, the activity of trunk musculature during upper and lower body resistance exercises (5, 8, 13, 17, 19, 20, 22, 26, 27, 28) has been studied and shows inconsistent results.

Decrease in Agonist Activation

There are five research studies that reported a decrease in agonist EMG activity when exercises were performed on an unstable platform. In 2002, Behm, Anderson, and Curnew (4) examined EMG levels on the quadriceps and plantarflexor groups during isometric MVC. Quadriceps activity decreased 11%, which was considered statistically significant. The authors also used an alternate measurement, the Interpolated Twitch Technique, which is used to measure the level of inactivation in muscle tissue during and after contraction. These results were more dramatic, reporting a 44% lower result in quadriceps activity for unstable condition. Two years later, Anderson and Behm (2) again collaborated to study the effects of unstable platforms on dynamic squat exercise. Squats were performed against no resistance, 29.5 kg, and 60% of body mass. Their results showed that standing on two Dyna-Discs increased the activity of the soleus muscle, decreased the activity of the vastus lateralis, and produced no difference in activity of the biceps femoris. In 2006, McBride, Cormie, and Deane (21) studied EMG readings during an isometric MVC squat exercise. They reported 37% and 34% decreases in vastus lateralis and vastus medialis EMG levels, respectively, when the exercise was performed with each foot placed on a DynaDisc, compared to a stable platform. In 2010, McBride et al. (22) recorded EMG measurements at the quadriceps, hamstrings, and erector spinae while testing dynamic squat exercises with loading values that were equal to the 1RM for each platform type. While both groups reported decreased lower extremity EMG readings for unstable condition, the differences were more pronounced under relative loading conditions. The authors argue that this may be an indication that relative loading values provide a more accurate assessment of muscle activity during unstable exercise, as the decrease in output is consistent with the decrease in muscle activation. The same year, Kohler, Flanagan, and Whiting (13) studied middle deltoid and triceps muscle activation while performing the seated shoulder press with barbell and dumbbell loads of 10RM on stable (bench) and unstable (Swiss ball) platforms. Middle deltoid and triceps activity with the barbell decreased 4% and 14%, respectively, when sitting upright on the Swiss ball. Only triceps activity showed significant difference with dumbbell exercises, decreasing 4% on the Swiss ball. Each of these studies reported decreased force output during unstable exercise, which is consistent with the decrease in muscle activation.

No Change in Agonist Activation

Seven studies reported that there is not a significant difference in EMG activity with respect to platform type. In 2004, Anderson and Behm (1) studied EMG levels during dynamic (75% 1RM) and isometric (75% MVC) chest press exercises for the pectoralis major, deltoid, triceps brachii, latissimus dorsi, and rectus abdominis, and found the only significant difference was for contraction type, regardless of platform. In 2006, Marshall and Murphy (20) performed a similar study at 60% 1RM during dynamic chest press, measuring activation of the pectoralis major, anterior deltoid, biceps brachii, triceps brachii, rectus abdominis, and transverse abdominis/internal oblique. No significant differences in activation were found except for the anterior deltoid and trunk muscles, which exhibited greater EMG output on the unstable platform. In 2008, Goodman et al. (8) recorded EMG activity for the Smith machine 1 RM chest press when performed on a bench and with a Swiss ball supporting the head and shoulders. No EMG differences were found based on platform for the pectoralis major, anterior deltoid, latissimus dorsi, external oblique, triceps brachii, or biceps brachii. In the same year, Wahl and Behm (28) compared EMG activity during standing, isometric body weight squatting, and various lower extremity exercises in highly resistance trained athletes on a variety of unstable platforms. Platforms included the floor, DynaDiscs, BOSU up, BOSU down, wobble board, and standing on a Swiss ball. Measurements were taken at the soleus, biceps femoris, rectus femoris, lumbosacral erector spinae, and lower abdominal muscles. During squatting posture, the majority of muscles measured showed no significant differences between floor, DynaDisc, BOSU up, and BOSU down conditions. However, the instability of the wobble board and the Swiss ball significantly increased soleus and lower abdominal activity. While the increased instability of the wobble board caused varying results, the traditional unstable resistance training platforms caused no significant differences in muscle activation. In 2010, Uribe et al. (26) compared dynamic seated shoulder press and supine chest press exercises at 80% 1RM on a bench and on a Swiss ball. Measurements were taken at the anterior deltoid, pectoralis major, and rectus abdominis. No significant differences were recorded. The same year, Sparkes and Behm (24) recorded EMG measurements of the triceps brachii and pectoralis major during chest press maximum voluntary isometric contraction as part of an 8-week instability resistance training protocol. They also calculated neuromuscular efficiency (NE), which is described as the ratio of EMG readings to force production, as a way to simultaneously evaluate force production and muscle activation. Although NE significantly increased during unstable chest press in both triceps and pectorals, it is primarily due to the decrease in force output. Muscle activation differences were insignificant.

Increase in Agonist Activation

Some research has reported an increase in muscle activity due to unstable exercise platforms. In 2006, Lehman et al. (19) examined EMG activity of the pectoralis major and triceps brachii during a variety of closed kinetic chain push-up exercises. Data was normalized to MVC, which was measured prior to data collection, but the actual measurements were taken during dynamic exercise. Results showed that exercise on a Swiss ball increased triceps activity, but not pectoralis major activity. In 2008, Oliveira, Carvalho and Brum (23) investigated muscle activation during three isometric closed-kinetic chain exercises: wall press, push-up, and end-range chest press. They reported that unstable surfaces caused an increase in anterior deltoid activity in all exercises, an increase in trapezius activity during wall press, and a decrease in pectoralis major and serratus anterior activity during push-ups. In 2011, Araujo et al. (3) found that muscle activation of the pectoralis major, biceps brachii, triceps brachii, and posterior deltoid was greater during one-arm push-up exercises on a Swiss ball than on a stable surface.

Trunk Muscle Activation

The data presented so far have focused on analyzing the prime movers of the body during exercise on stable and unstable platforms. However, the role of the trunk musculature in providing a stable base for movement must also be considered. The stability of the core during certain exercises on unstable platforms may affect the ability of the prime movers to produce a coordinated force on an external object. An increased demand on the trunk stabilizers while on unstable surface may indicate a decrease in stability of the lumbopelvic hip complex and spine, which act as the foundation for force production in the human body. Marshall and Murphy (20) found that activity of the rectus abdominis and lower abdominals were greater during the 60% 1RM chest press while lying supine on a stability ball than a stable surface. Vera-Garcia et al. (27) found similar results during situp exercises in 4 different stability conditions. Anderson and Behm (2) reported that an unstable surface increased trunk muscle activity during dynamic squat exercise at 60% body mass. Lehman et al. (19) reported that performing a variety of dynamic push-up exercises on a Swiss ball rather than a stable surface increased activity of the rectus abdominis, but not the external oblique. Behm et al. (5) examined trunk muscle activity during unilateral and bilateral chest press on stable and unstable platforms. Significant effects were found during bilateral chest press for upper and lower erector spinae, but only a trend was present for lower abdominal stabilizers. Unilateral exercises were reported to produce a much greater activation of lower abdominals and erector spinae than bilateral exercises when the exercise limb was contralateral to the trunk muscles measured. Conversely, Kohler, Flanagan, and Whiting (13) reported variability in activation of trunk muscles while studying the effect of unstable platforms and unstable loads during seated shoulder press with relative loading values. Goodman et al. (8) reported no change in muscle activation in the external oblique and rectus abdominis during supine 1RM chest press on a bench and a Swiss ball. Uribe et al. (26) found similar results for the 80% 1RM supine chest press and overhead shoulder press on a bench and a Swiss ball. Lehman et al. (17) also reported no significant differences in muscle activation for platform type in trunk muscles during a series of upper extremity resistance exercises. Resistance levels were reported from 10-40 lbs, but were not controlled for % 1RM. McBride et al. (22) reported no significant difference in erector spinae activity during dynamic squat exercise at 70%, 80%, and 90% 1RM. Wahl and Behm (28) also reported that lower abdominal and lower erector spinae activity did not change significantly during isometric free squats and other lower extremity body weight exercises in highly trained subjects.

Summary and Conclusion

Previous research on this subject is clear in some areas, but inconsistent in others. It seems clear that unstable platforms cause a decrease in the force output, which has been measured in isometric and isotonic conditions. Among lower extremity exercises, EMG measurements have shown a decrease in agonist muscle activation with unstable surfaces (2, 4, 21, 22) that coincides with the decrease in force output reported during similar exercises (4, 7, 21, 22). The only exception is Wahl and Behm (28), who studied highly resistance trained individuals, concluding that training status affects the level of lower extremity muscle activation on unstable platforms. However, their protocol differed from most other studies in that the exercises did not involve any external resistance or MVC. For upper extremity exercises, EMG measurements have consistently shown that unstable platforms cause no significant change in agonist muscle activation levels during isometric and dynamic exercise (1, 8, 20, 24, 26). Interestingly, force output for the upper extremity still seems to decrease (1, 3, 15, 16, 24) in spite of the lack of a significant change in muscle activity. The only exception to these results is Kohler, Flanagan and Whiting (13), who reported a decrease in activity of the triceps during 10RM shoulder press with both barbell and dumbbell loads and a decrease in middle deltoid activity, but only while using the barbell. Closed kinetic chain upper body exercises (i.e. push-ups) appear to affect the shoulder musculature differently. Most results show that these exercises cause an increase in agonist activation of the shoulder (3, 19, 23). Limited evidence exists in regard to the role of the scapular stabilizers during this type of exercise. Lehman, Gilas, and Patel (18) studied these muscles during a variety of closed kinetic chain push-up exercises. No external resistance was provided other than individual body mass, which averaged 83.3 ± 10.9 kg. No significant effect for surface type was reported.

The activity of trunk muscles during unstable resistance exercise is not very consistent. For trunk muscle activation during lower extremity exercise, measurements increased during dynamic squat exercise at 60% body mass (2), but not during dynamic squat ranging from 70-90% 1RM (22) or during isometric squatting and body weight exercises (28). For trunk muscle activation during upper extremity exercise, measurements increased during dumbbell chest press with a load of 30 lbs (5), 60% 1RM dumbbell chest press (20), and during closed kinetic chain pushup variations (19). However, no significant differences were present during 10RM dynamic shoulder press (13), 80% 1RM dynamic shoulder and chest press (26), 1RM Smith machine dynamic chest press (8), and a variety of dynamic upper extremity exercises (including chest press) using 10-40 lb resistance (17).

An important consideration during EMG research is the presence of isometric measurements. Measuring muscle activation during isotonic exercise, particularly when on an unstable surface, introduces variables that are much more difficult to control and measure accurately (14). However, only a handful of the research groups presented have used isometric measures in their protocol. Behm, Anderson and Curnew (4) reported a decrease in agonist activity during open kinetic chain isometric contractions of the lower extremity while seated on a Swiss ball. McBride, Cormie and Deane (21) also found a decrease in agonist activity, but during an isometric MVC squat exercise. Wahl and Behm (28) found no change in isometric muscle activity during squatting, but their subjects did not perform MVC, only squatting posture. For upper extremity exercise, isometric agonist activity appears to increase when the upper extremity pushes against an unstable surface (3, 23), but not when the subject lies supine on an unstable surface pushing against a stable surface like a fixed strain gauge (1, 24). Interestingly, none of the research that has investigated trunk activity during resistance exercise on unstable platforms has measured during isometric MVC of the upper or lower extremities.

In summary, while the presence of unstable surfaces significantly decreases force output among all types of exercise measured, the activity of agonist and trunk muscles appears to depend largely on the position and type of exercise performed. Trunk muscle activity during unstable resistance exercise still requires further research, and more consistent methodology and isometric analysis may provide more consistent results in force output and activation measures. Finally, the decrease in force output of the upper extremity without a significant change in muscle activity is a discrepancy that has not yet been accounted for in research. Understanding the activity of antagonist and trunk stabilizing musculature during these exercises may help clarify the reason for these seemingly conflicting results.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to compare muscle activation of the agonist, antagonist and trunk stabilizers during isometric maximal and submaximal chest press exercise performed on stable and unstable platforms. This section will describe the subjects, instruments, procedures, design, and analysis of this study.

Subjects

Male recreational athletes (n=32) were recruited to participate in this study, however only 30 were found to meet study inclusion criteria (see Table 1). Furthermore, data from 3 subjects were compromised due to technical errors in data collection. Subjects were recruited from personal fitness and weight training courses on the campus of Texas State University-San Marcos, Texas. Each subject had at least one year of resistance training experience and at least six months of experience with resistance training on unstable platforms (i.e. stability or physio-ball, BOSU ball, Dyna-Disc, etc). Subjects were excluded from this study for the following reasons: obesity, a history of known cardiac, respiratory, metabolic disease, a history of physical injuries that would limit exercise ability, or shoulder or spine pathology or surgery. Each subject was required to read and sign a consent form prior to participation in this study, which was approved by the Texas State University Institutional Review Board. Each subject also completed a demographics form, general health history questionnaire, and the Disabilities of the Arm, Shoulder, and Hand (DASH) scale (10). The DASH scale measures function of the upper extremity for activities of daily living from 0-100, with a higher score indicating greater disability. A score below 10 is considered better than the average population (11).

Procedures

Familiarization

Subjects in this study performed an isometric chest press exercise while lying supine on an exercise bench and a Thera-Band Exercise Ball (The Hygenic Corporation, Akron, OH). A familiarization procedure was conducted no more than 10 days prior to data collection. This visit allowed the subject to experience the isometric chest press on the stable and unstable surfaces, learn the protocol of the data collection procedure, and measure maximum voluntary contraction (MVC) values for both platform types.

Subjects were first placed on the stable bench and performed two to three trials at increasing intensities. Using BIOPAC Acqknowledge 4.1 software (BIOPAC Systems Inc., Goleta, CA), a graph plotting the subject's force output was projected in real time onto the ceiling so that subjects could use visual feedback to monitor their force production. After the subject felt comfortable with the exercise, they were given two to four minutes of rest, followed by three MVC trials.

Each trial began with the subject lying supine and resting completely. All trials were timed using a metronome set at 60 bpm. Upon the start of data collection, a verbal cue ("Up!") was given, and the subject was given three seconds to assume the exercise position and be prepared to begin. After the three second countdown, another verbal cue ("Go!") was given, upon which the subject had been previously instructed to take two seconds to smoothly ramp up to the target force output. For MVC trials, the subject used the ramping period to progress toward maximum effort. The subject then held maximal contraction for at least three seconds. After the researcher determined that sufficient data had been collected, a final verbal cue ("Stop!") was given, and the subject was permitted to rest. In this manner, each contraction lasted approximately five to six seconds. To reduce the confounding effects of fatigue, a rest period of 15-30 seconds was given between each trial, with two to four minutes of rest between each set of three trials.

This procedure was repeated during the familiarization visit while lying supine on the stability ball. The subject's maximal force output for each platform type was calculated using the average of three maximal trials. These values were used to estimate submaximal values (75% and 50%) during the data collection procedure.

Data Collection

Force and electromyographical measurements were recorded at the Texas State University Biomechanics/Sports Medicine Laboratory using an 8-channel BIOPAC

MP150 Data Acquisition System (BIOPAC Systems Inc., Goleta, CA). Recorded frequencies were pre-amplified and set between 10Hz and 1000Hz using a band pass filter. In order to reduce electrical impedance, skin sites had hair clipped and were cleansed with alcohol wipes. Electrodes were in place at least 5 minutes prior to data collection to ensure maximum electrode adhesion and accurate EMG recording. BIOPAC EL-503 self-adhesive disposable gel surface electrodes were placed on the subject's dominant side (i.e. Which arm would you throw a ball with?). Electrodes were placed approximately three cm apart over the following muscles: pectoralis major, anterior deltoid, posterior deltoid, infraspinatus, latissimus dorsi, trapezius, and transverse abdominis/internal oblique (see Table 2 for placement guidelines). A reference electrode was placed at the spinous process of C7. Signals were processed and filtered to provide a mean integral EMG voltage over a set time duration using Acqknowledge 4.1 software. The mean and peak levels of electrical activity in each muscle group were recorded as microvolt root mean square (µVRMS) units.

Maximal and sub-maximal contractions were performed against two handles that were separately attached via industrial strength cables to the base of a squat rack (see Figure 1). On the dominant side, an Omega LCR series S-Beam strain gauge (OMEGA Engineering, Stamford, CT) was fixed to the cable. This strain gauge transmitted tension data to the BIOPAC system, which was calibrated to graph force output (N) during contractions. The cables and platforms were adjusted to allow for joint angle normalization between subjects. Isometric contractions were performed with the subject lying supine, the shoulders in 90° of abduction, the elbows in 90° of flexion, and a 90° knee joint angle. During stability ball trials, subjects were instructed to raise their hips to maintain a flat abdomen during the length of the trial. Position was confirmed by the researcher via goniometer at each joint angle, and by the use of a level to ensure that the hands were at even heights during contraction, and that the subject lay parallel to the ground (level from AC joint to lateral femoral condyle on dominant side). To maintain consistency between subjects, only one stability ball was used for all testing purposes. To ensure consistent joint positioning for subjects with varying body sizes, ½" plywood spacers were placed under the subject's feet or underneath the bench/stability ball as needed. Ball pressure was maintained by inflating to manufacturer's specifications (65 cm diameter or 204 cm circumference) and ensuring consistent ball circumference via tape measure immediately prior to each subject's data collection visit.

During stability ball trials, the ball would deform as greater force was exerted. This presented a challenge to maintain accurate joint positioning during contractions. Prior to these trials, the handles were adjusted so that the resting glenohumeral joint position was approximately 100° horizontal abduction. It was estimated that the deformation of the stability ball during maximal contractions would allow the glenohumeral joint approximately 10° of change in the transverse plane, resulting in the desired exercise position.

All procedures were randomized using a random number generator. Maximal contractions followed the exact protocol as stated above for the familiarization visit. Submaximal contractions followed the same protocol while using the visual feedback system to hold isometric contraction at the target force output for at least three seconds.

The root mean square of EMG output (mV), peak muscle activation (mV), and force Newton output (N) were calculated and used for statistical analysis. All measurements were calculated post-filtration to reduce confounding effects of noise and cross-talk.

Using a pilot study of 3 subjects, it was determined that a sample size of at least 25 subjects would be necessary to detect a moderate effect (partial ETA^2 of 0.06 or higher) with statistical power of at least 0.80. This estimate was confirmed by repeating power analysis after the first 10 subjects. A sample size of 30 subjects was chosen to account for possible participant drop out or sample attrition. The pilot study also provided an opportunity to evaluate test procedures and make changes to improve accuracy of results.

Design and Analysis

Demographic data were analyzed using central tendency scores. Statistical analysis was performed using a repeated measures crossover experimental design. Data were analyzed using a Repeated Measures Analysis of Variance (ANOVA) test. The independent variable was platform type (bench vs. stability ball), which also served as the repeated measures. The dependent variables of this study were the differences in resting and exercise conditions for force output, root mean square of muscle activation, and peak muscle activation of each individual muscle group. Results were considered significant at $p \leq 0.05$. Partial ETA^2 was calculated, with a score above 0.14 indicating significant effect size.

CHAPTER IV

MANUSCRIPT

Introduction

Unstable exercise platforms have become an increasingly common part of resistance training workouts and sport performance regimens in fitness and health care settings (12, 29). Some of the benefits proposed by the manufacturers of these platforms include improved balance, proprioception, and core stability. Recent investigations have sought to determine how the presence of instability affects force output and activation of agonist muscles during the supine chest press (1, 8, 16, 20, 24, 26). Results suggest that an unstable platform causes no significant change in agonist activation levels (1, 8, 20, 24, 26). However, force output significantly decreases, even in the presence of statistically similar agonist EMG activity (1, 16, 24).

Anderson and Behm (1) proposed that this discrepancy might be explained by a change in neural input to the musculature favoring joint stability over force output. This suggests that a co-contraction mechanism at the glenohumeral joint might be affecting the net force output of the chest press. However, this hypothesis has not been effectively investigated.

The purpose of this study is to examine the effect of unstable platforms on force output and agonist EMG activity during the supine chest press. This study investigated the EMG activity of the posterior shoulder and lower abdominal musculature during the supine chest press under stable and unstable conditions. The results of this study provide more specific information about the use of instability for sports medicine and fitness professionals. If the force output decrease is caused by a co-contraction mechanism at the glenohumeral joint, then the strength training effect of agonist muscles may be achieved with a simultaneous training effect to the posterior shoulder musculature. In combination with the potential for an increase in core muscle activation, the supine chest press on a stability ball could prove to be an efficient exercise to train the posterior shoulder and core while also achieving maximal strength gains targeted by the chest press.

Methods

Experimental Approach to the Problem

The effect of instability on the supine chest press was investigated using a repeated measures crossover experiment. Following a familiarization protocol, subjects performed maximal and submaximal isometric contractions while lying supine on an exercise bench and a stability ball. Contractions were performed against a strain gauge, with surface electrodes fixed over various muscles of the anterior and posterior shoulder and the lower abdominals to record average and peak muscle activation levels. This data was used to compare force output and muscle activation levels of each muscle between platform types.

Subjects

Male recreational athletes (n=30) were recruited to participate in this study (see Table 1). However, data from 3 subjects were compromised due to technical errors in data collection. Using a pilot study of 3 subjects, it was determined that a sample size of at least 25 subjects would be necessary to detect a moderate effect (partial ETA^2 of 0.06 or higher) with statistical power of at least 0.80. This estimate was confirmed by repeating power analysis after the first 10 subjects. A sample size of 30 subjects was chosen to account for possible participant drop out or sample attrition. Subjects were recruited from personal fitness and weight training courses on the campus of Texas State University-San Marcos, Texas. Each subject had at least one year of resistance training experience and at least six months of experience with resistance training on unstable platforms (i.e. stability or physio-ball, BOSU ball, Dyna-Disc, etc). Subjects were excluded from this study for the following reasons: obesity, a history of known cardiac, respiratory, metabolic disease, a history of physical injuries that would limit exercise ability, or shoulder or spine pathology or surgery. Each subject was required to read and sign a consent form prior to participation in this study, which was approved by the Texas State University Institutional Review Board. Each subject also completed a demographics form, general health history questionnaire, and the Disabilities of the Arm, Shoulder, and Hand (DASH) scale (10). The DASH scale measures function of the upper extremity for activities of daily living from 0-100, with a higher score indicating greater disability. A score below 10 is considered better than the average population (11).

Table 1. Subject Demographics

Age	22.9 ± 2.8 yrs
Height	1.8 ± 0.1 m
Weight	83.0 ± 9.4 kg
RT Exp	7.2 ± 3.9 yrs
DASH Score	1.1 ± 1.5

RT – Resistance Training
DASH – Disability of Arm, Shoulder, and Hand

Procedures

Familiarization

Subjects in this study performed an isometric chest press exercise while lying supine on an exercise bench and a Thera-Band Exercise Ball (The Hygenic Corporation, Akron, OH). A familiarization procedure was conducted no more than 10 days prior to data collection. This visit allowed the subject to experience the isometric chest press on the stable and unstable surfaces, learn the protocol of the data collection procedure, and measure maximum voluntary contraction (MVC) values for both platform types.

Subjects were first placed on the stable bench and performed two to three trials at increasing intensities. Using BIOPAC Acqknowledge 4.1 software (BIOPAC Systems Inc., Goleta, CA), a graph plotting the subject's force output was projected in real time onto the ceiling so that subjects could use visual feedback to monitor their force production. After the subject felt comfortable with the exercise, they were given two to four minutes of rest, followed by three MVC trials.

Each trial began with the subject lying supine and resting completely. All trials were timed using a metronome set at 60 bpm. Upon the start of data collection, a verbal cue ("Up!") was given, and the subject was given three seconds to assume the exercise position and be prepared to begin. After the three second countdown, another verbal cue ("Go!") was given, upon which the subject had been previously instructed to take two seconds to smoothly ramp up to the target force output. For MVC trials, the subject used the ramping period to progress toward maximum effort. The subject then held maximal contraction for at least three seconds. After the researcher determined that sufficient data had been collected, a final verbal cue ("Stop!") was given, and the subject was permitted to rest. In this manner, each contraction lasted approximately five to six seconds. To reduce the confounding effects of fatigue, a rest period of 15-30 seconds was given between each trial, with two to four minutes of rest between each set of three trials.

This procedure was repeated during the familiarization visit while lying supine on the stability ball. The subject's maximal force output for each platform type was calculated using the average of three maximal trials. These values were used to estimate submaximal values (75% and 50%) during the data collection procedure.

Data Collection

Force and electromyographical measurements were recorded at the Texas State University Biomechanics/Sports Medicine Laboratory using an 8-channel BIOPAC MP150 Data Acquisition System (BIOPAC Systems Inc., Goleta, CA). Recorded frequencies were pre-amplified and set between 10Hz and 1000Hz using a band pass filter. In order to reduce electrical impedance, skin sites had hair clipped and were cleansed with alcohol wipes. Electrodes were in place at least 5 minutes prior to data collection to ensure maximum electrode adhesion and accurate EMG recording. BIOPAC EL-503 self-adhesive disposable gel surface electrodes were placed on the subject's dominant side (i.e. Which arm would you throw a ball with?). Electrodes were placed approximately three centimeters apart over the muscle belly of the following muscles: pectoralis major, anterior deltoid, posterior deltoid, infraspinatus, latissimus dorsi, trapezius, and transverse abdominis/internal oblique (see Table 2 for placement guidelines). A reference electrode was placed at the spinous process of C7. Signals were processed and filtered to provide a mean integral EMG voltage over a set time duration using the Acqknowledge 4.1 (BIOPAC Systems Inc., Goleta, CA) data processing software. The mean and peak levels of electrical activity in each muscle group were recorded as microvolt root mean square (µVRMS) units.

Table 2. Electrode Placement Guidelines

Pec Major	Cram (6)
Ant Deltoid	SENIAM (25)
Post Deltoid	SENIAM (25)
Infraspinatus	Cram (6)
Trapezius	Konrad (14)
Lat Dorsi	Hintermeister (9)
TA/IO*	Marshall and Murphy (20)

*Transverse Abdominis/Internal Oblique

Maximal and sub-maximal contractions were performed against two handles that were separately attached via industrial strength cables to the base of a squat rack (see Figure 1). On the dominant side, an Omega LCR series S-Beam strain gauge (OMEGA

Engineering, Stamford, CT) was fixed to the cable. This strain gauge transmitted tension data to the BIOPAC system, which was calibrated to graph force output (N) during contractions. The cables and platforms were adjusted to allow for joint angle normalization between subjects. Isometric contractions were performed with the subject lying supine, the shoulders in 90° of abduction, the elbows in 90° of flexion, and a 90° knee joint angle. During stability ball trials, subjects were instructed to raise their hips to maintain a flat abdomen during the length of the trial. Position was confirmed by the researcher via goniometer at each joint angle, and by the use of a level to ensure that the hands were at even heights during contraction, and that the subject lay parallel to the ground (level from acromioclavicular joint to lateral femoral condyle on dominant side). To maintain consistency between subjects, only one stability ball was used for all testing purposes. To ensure consistent joint positioning for subjects with varying body sizes, ½” plywood spacers were placed under the subject’s feet or underneath the bench/stability ball as needed. Ball pressure was maintained by inflating to manufacturer’s specifications (65 cm diameter or 204 cm circumference) and ensuring consistent ball circumference via tape measure immediately prior to each subject’s data collection visit.

Figure 1. Supine Chest Press on Stability Ball

During stability ball trials, the ball would deform as greater force was exerted. This presented a challenge to maintain accurate joint positioning during contractions. Prior to these trials, the handles were adjusted so that the resting glenohumeral joint position was approximately 100° horizontal abduction. It was estimated that the deformation of the stability ball during maximal contractions would allow the glenohumeral joint approximately 10° of change in the transverse plane, resulting in the desired exercise position.

All procedures were randomized using a random number generator (www.random.org). Maximal contractions followed the exact protocol as stated above for the familiarization visit. Submaximal contractions followed the same protocol while using the visual feedback system to hold isometric contraction at the target force output for at least three seconds.

The root mean square of EMG output (mV), peak muscle activation (mV), and force Newton output (N) were calculated and used for statistical analysis. All measurements were calculated post-filtration to reduce confounding effects of noise and cross-talk.

Statistical Analyses

Data from 3 subjects were excluded, therefore only 27 subjects were found to be complete and acceptable for final data analysis. Demographic data were analyzed using central tendency scores. Statistical analysis was performed using a repeated measures crossover experimental design. Data were analyzed with STATA Version 12 (College Station, TX), using a Repeated Measures Analysis of Variance (ANOVA) test. The independent variable was platform type (bench vs. stability ball), which also served as the repeated measures. The dependent variables of this study were the differences in resting and exercise conditions for force output, root mean square of muscle activation, and peak muscle activation of each individual muscle group. Results were considered significant at $p \leq 0.05$. Partial ETA^2 was calculated, with a score above 0.14 indicating significant effect size.

Results

Data were collected from 30 subjects, with 3 data sets removed due to technical errors during data collection. A pilot study indicated that, in order to detect a moderate effect (partial ETA^2 of 0.06 or higher) with statistical power of at least 0.80, a sample size of at least 25 subjects would be required. Almost all test-retest reliability ICC values for force, mean EMG output, and peak EMG output demonstrated high or very high reliability appropriate for analysis (0.94 ± 0.09). However, the reliability coefficients of the infraspinatus measurements from MVC bench trials for both mean (.71) and peak (.52) EMG output and the latissimus dorsi measurements for peak EMG output from MVC bench trials (.73), 75% MVC ball trials (.73), and 50% MVC ball trials (.33) were unacceptable; consequently no analyses were conducted on these variables.

Repeated measures ANOVA was used to determine differences in force, mean EMG, and peak EMG output between the bench and stability ball testing conditions. For MVC force trials, significant differences were observed between testing conditions ($p = .0001$, partial $eta^2 = .45$). Mean force output was significantly lower (15% decrease) for the stability ball testing condition (see Table 3).

Table 3. Mean force output results during MVC trials (n=27)

	Force (N)
Bench	344.36 ± 71.43
Ball	293.05 ± 64.51

During MVC trials, significant differences were observed between testing conditions for mean EMG output of the pectoralis major ($p = .0099$, partial eta^2 = .23) and anterior deltoid ($p = .0272$, partial eta^2 = .17), and for peak EMG output of the pectoralis major ($p = .0181$, partial eta^2 = .20). In all cases, EMG output was significantly lower (24%, 14%, and 16% decrease, respectively) for the stability ball testing condition (see Table 4).

Table 4. Statistically significant mean and peak EMG output results from MVC trials (n=27)

	Mean EMG (mV)		**Peak EMG (mV)**
	Pec Maj	**Ant Delt**	**Pec Maj**
Bench	0.22 ± 0.12	0.47 ± 0.21	0.88 ± 0.47
Ball	0.16 ± 0.08	0.40 ± 0.19	0.73 ± 0.33

Pec Maj - pectoralis major, Ant Delt - anterior deltoid

During 75% MVC trials, significant differences were observed between testing conditions for mean EMG output of the anterior deltoid ($p = .0229$, partial eta^2 = .18) and transverse abdominis/internal oblique ($p = .0079$, partial eta^2 = .25), and for peak EMG output of the anterior deltoid ($p = .04$, partial eta^2 = .15) and infraspinatus ($p = .0185$, partial eta^2 = .20). Mean and peak EMG output for the anterior deltoid were significantly lower (12% and 10% decrease, respectively) for the stability ball testing condition, while mean EMG output of the TA/IO and peak EMG output of the infraspinatus were significantly higher (51% and 21% increase, respectively) for the stability ball testing condition (see Table 5).

Table 5. Statistically significant mean and peak EMG output results from 75% MVC trials (n=27)

	Mean EMG (mV)		**Peak EMG (mV)**	
	Ant Delt	**TA/IO**	**Ant Delt**	**Infra**
Bench	0.35 ± 0.16	0.07 ± 0.06	1.76 ± 0.96	0.34 ± 0.23
Ball	0.31 ± 0.14	0.10 ± 0.07	1.58 ± 0.70	0.42 ± 0.32

Ant Delt - anterior deltoid, TA/IO – transverse abdominis / internal oblique, Infra – infraspinatus

During 50% MVC trials, significant differences were observed between testing conditions for mean EMG output of the pectoralis major ($p = .0129$, partial eta^2 = .21), anterior deltoid ($p = .0049$, partial eta^2 = .27), and transverse abdominis/internal oblique ($p < .0001$, partial eta^2 = .50), and for peak EMG output of the anterior deltoid ($p = .0022$, partial eta^2 = .31), and transverse abdominis/internal oblique ($p < .0001$, partial eta^2 = .51). Mean EMG output of the pectoralis major and both mean and peak EMG output of the anterior deltoid were significantly lower (18%, 14%, and 13%, respectively) for the stability ball testing condition, while mean and peak EMG output of the transverse abdominis/internal oblique were significantly higher (133% and 140% increase, respectively) for the stability ball testing condition (see Table 6).

Table 6. Statistically significant mean and peak EMG output results from 50% MVC trials (n=27)

	Mean EMG (mV)			Peak EMG (mV)	
	Pec Maj	**Ant Delt**	**TA/IO**	**Ant Delt**	**TA/IO**
Bench	0.11 ± 0.05	0.23 ± 0.11	0.03 ± 0.03	1.26 ± 0.65	0.15 ± 0.15
Ball	0.09 ± 0.04	0.20 ± 0.10	0.06 ± 0.05	1.10 ± 0.57	0.35 ± 0.33

Pec Maj - pectoralis major, Ant Delt - anterior deltoid, TA/IO – transverse abdominis/internal oblique

Discussion

Previous research has reported that replacing bench with a stability ball during the supine chest press results in a decrease in force output with no significant changes in agonist muscle activation (1, 8, 16, 20, 24, 26). The purpose of this investigation was to confirm previous findings and determine whether a co-contraction mechanism is present at the glenohumeral joint during the unstable chest press. The most significant finding from this investigation was a decrease in agonist EMG activity on the unstable surface during MVC trials. The decrease in agonist EMG activity correlated with a decrease in force output in the presence of instability. This investigation also found that none of the tested posterior shoulder muscles studied showed any significant difference in mean or peak EMG activity during any of the trials, with the exception of peak EMG of the infraspinatus during 75% trials.

Some previous investigations have examined muscle activation during dynamic exercise (8, 16, 20, 26). Isometric contraction is the standard for surface EMG studies that use root mean square measurements. The activity level of a specific muscle may vary based on joint angle and position, and dynamic exercise may increase the variability of EMG measurement results. Combining dynamic exercise with an unstable surface may further decrease the likelihood of maintaining accurate joint positioning. Isometric contraction reduces the number of variables at play during data collection and provides greater control over the research conditions.

The presence of instability presents challenges even while utilizing isometric contractions. As stated previously, the deformation of the stability ball during force production can still produce small joint angle changes, meaning that the exercise is not truly isometric. This is one of the limitations of this investigation that must be acknowledged even if it cannot be easily resolved.

There have been cases where isometric testing has produced differing results from the current study. Previous investigations found that isometric maximal force decreased without a significant change in agonist EMG activity during MVC and 75% MVC trials (1, 24). Interestingly, agonist muscles responded differently to varying intensities in the current investigation. At MVC, mean and peak activation of the pectoralis major decreased during unstable trials, while only mean activation of the anterior deltoid decreased. Perhaps most notably, the pectoralis major showed no significant differences in mean or peak activation at 75% MVC, while both mean and peak activation of the anterior deltoid decreased during unstable trials. Finally, at 50% MVC, mean activation of the pectoralis major and both mean and peak activation of the anterior deltoid decreased in the presence of instability. The behavior of the pectoralis major at 75% MVC is comparable to the results of one previous study (1), but the results at MVC differ.

It is important to note that the effect sizes for each of the significant findings were considerably high, with partial ETA^2 values ranging from 0.15 to 0.51. Partial ETA^2 is a coefficient, ranging from 0 to 1, that conveys the amount of variation among the dependent variables that can be attributed to the independent variable in question, as opposed to random chance. In physiological research, a score of 0.14 is considered significant. Effect sizes are not recorded in this manner among any previous experiments that have been performed for this particular study design (1, 8, 16, 20, 24, 26). The combination of substantial effect sizes and a larger sample size indicate that the results from this research carry significant value, even in opposition to previous research.

Another interesting finding is the response of the TA/IO muscle group. It was anticipated that the lower abdominals would present significantly greater activity levels on the stability ball, but this was only the case during submaximal trials. During MVC, it appears that the TA/IO muscle group is equally active regardless of platform type. This is consistent with the findings of Goodman et al. (8) during 1RM dynamic chest press. The current findings at submaximal intensities are consistent with the results of Marshall and Murphy (20) during 60% 1RM dynamic chest press. No significant changes in activation were found in the rectus abdominis by Uribe et al. (26) during 80% 1RM dynamic chest press. The effect of instability during resistance training exercise on other abdominal muscles is not clear (8, 13, 20, 26). Behm et al. (5) reported evidence that unilateral exercise on a stable surface is more effective at activating the lower abdominals and erector spinae than the unstable chest press or shoulder press, particularly for the core musculature opposite of the exercise side. This is an area of instability research that warrants further investigation.

A statistically significant increase in peak EMG output was present for the infraspinatus during 75% MVC stability ball trials. No significant change was recorded during MVC or 50% MVC trials, but because test-retest reliability of peak EMG output during MVC trials did not meet established criteria, this study is not able to conclusively state the effect of instability on activity of the infraspinatus during MVC trials. Test-retest reliability was also unacceptable for peak measures at all three intensities for the latissimus dorsi, but mean EMG output showed no significant difference between platforms. It is interesting to observe this change in the activation amplitude of the infraspinatus without the presence of a statistically significant increase in overall mean EMG activity during 75% MVC trials. It is possible that this change in amplitude is a result of the infraspinatus working to correct the position of the glenohumeral joint while balance on the stability ball is challenged during force production. By this hypothesis, further deformation of the stability ball via maximal force production would theoretically create greater joint position corrections, thus increasing the peak EMG output of the infraspinatus. Further research is warranted to clarify the role of the infraspinatus during this type of exercise.

There are a few important limitations to this research. This includes the previously mentioned effect of instability on joint angles during isometric contractions. Additionally, research using isometric exercise is limited to the joint angle that is tested. Therefore, any attempt to apply the results of this research to other joint positions, even during the same exercise, must be treated as an extrapolation of these results. This is especially important because the joint position examined in this research maintains the least mechanical advantage for the agonist muscles, which is commonly referred to as the “sticking point” of the chest press. It is possible that joint positions with a greater mechanical advantage would produce in different results.

This investigation has important implications to the fields of strength training and rehabilitation. Results suggest that the use of stability balls as a replacement for a stable bench during the supine chest press may not be appropriate when the primary result of training is an increase in upper body strength. Even at submaximal intensities, the force output and EMG activity of the pectoralis major and anterior deltoid can show significant decreases. Additionally, similar activation levels of the TA/IO muscle group were found during MVC trials on both platform types, suggesting that maximal chest press may produce a similar training effect on the lower abdominals regardless of platform type. This may indicate that the use of instability during high intensity resistance training to increase activation of the core musculature may not be necessary. Performing the supine chest press on a stability ball is appropriate during submaximal exercise to increase activity of the lower abdominals, but a greater training effect may be achieved by performing the stable maximal chest press.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Previous research has reported that replacing bench with a stability ball during the supine chest press results in a decrease in force output with no significant changes in agonist muscle activation (1, 8, 16, 20, 24, 26). The purpose of this investigation was to confirm previous findings and determine whether a co-contraction mechanism is present at the glenohumeral joint during the unstable chest press. The most significant finding from this investigation was a decrease in agonist EMG activity on the unstable surface during MVC trials. The decrease in agonist EMG activity correlated with a decrease in force output in the presence of instability. This investigation also found that none of the tested posterior shoulder muscles studied showed any significant difference in mean or peak EMG activity during all trials, with the exception of peak EMG of the infraspinatus during 75% trials.

This investigation has important implications to the fields of strength training and rehabilitation. Results suggest that the use of stability balls as a replacement for a stable bench during the supine chest press may not be appropriate when the primary result of training is an increase in upper body strength. Even at submaximal intensities, the force output and EMG activity of the pectoralis major and anterior deltoid can show significant decreases. Additionally, similar activation levels of the TA/IO muscle group were found during MVC trials on both platform types, suggesting that stable maximal chest press may produce a similar training effect on the lower abdominals regardless of platform type. This may indicate that the use of instability during high intensity resistance training to increase activation of the core musculature may not be necessary. Performing the supine chest press on a stability ball is appropriate during submaximal exercise to increase activity of the lower abdominals, but a similar training effect may be achieved by performing the stable maximal chest press.

Recommendations for Further Study

Future studies investigating the use of unstable platforms on force output and EMG activity should consider the use of isometric contraction to improve the reliability of EMG measurement. A similar study design investigating the role of other core and spinal stabilizing musculature would be beneficial in confirming whether stable maximal chest press can produce a similar training effect when compared to maximal unstable chest press. The peak EMG effect present in the infraspinatus muscle could be verified using a combination of electromyography and biomechanical analysis. A motion tracking system could determine if peak EMG differences in muscle activation during the exercise coincide with positional changes of the shoulder and arm.

APPENDIX 1

CONSENT FORM

I agree to participate in the research study named: An Electromyographical Analysis of Shoulder and Trunk Muscles During Chest Press on Stable and Unstable Platforms *(IRB# 2012U3691).* I understand that the person responsible for this research project is Rory McHardy ATC, LAT, CES of the Department of Health and Human Performance, Texas State University (512) 245-2561. Rory can be reached by email at r_m186@txstate.edu.

I. Purpose

Weight training using unstable platforms has become very popular among health and fitness professionals. Research has shown that the human body is less able to produce force when placed on an unstable surface. However, the effect that instability has on electrical output of muscles during exercise is not clear. In order to use this training style to improve health and fitness, it is important to understand how the body changes during exercise on unstable platforms. The purpose of this study is to gain knowledge about how the body changes during exercise on unstable surfaces.

The study group will be at least 20 healthy subjects (18 to 35 years of age). They must have at least 3 years of weight training experience and at least 1 year of experience with exercise on unstable surfaces. They will be physically active, but not members of competitive college teams. Individuals will not be able to participate for the following reasons: obesity, a history of known cardiac, respiratory or metabolic disease, a history of physical injuries that would limit exercise ability, suffering from or taking medicine for a major physical or mental illness, or a history of shoulder pain or surgery. For this purpose, I will be required to answer questions that will give the researchers basic information about my physical and mental health and other personal information necessary for the study. Some examples of the questions are: “Are you currently suffering from a major physical or mental illness?”, “what medications are you currently taking?”, and “please list your chronic or serious illnesses”.

Before I participate, I certify to the program that I am in good health. I will be interviewed by health care professionals prior to participation who will determine if there are any reasons that I should not participate. For these reasons, it is important that I provide complete and accurate responses to the interviewer. I recognize that my failure to do so could lead to injury to myself during the study. I may refuse to answer any question.

If chosen to participate, I will perform the chest press on a stable bench and on a stability ball. There will be two visits, separated by at least 3 days. The first visit will be to measure the amount of weight I can chest press (1RM). This will be used to select the weight used in the second visit, which is where electrical measurements will be recorded. Prior to these two visits, I will be taught how to do the exercise correctly.

I may ask for a summary of findings at the end of the study.

II. Risks

I understand and have been informed that there is a risk of injury during this study. Exercise on unstable platforms can be dangerous, but the researchers will be careful to reduce the risk of injury from this study. I may also experience muscle soreness following the test. I have been asked to perform a regular weight training routine before this study. This will reduce the risk of feeling sore after the study. Someone that is trained in CPR will be present during the study. I have been told that I should ask that the study be stopped at any point if I feel unusual discomfort or pain. I will tell the researcher if I wish to stop at any time. Knowing the risk of injury, it is my desire to participate in this research study. If this research study causes me any physical injury, treatment may not be available at Texas State University or the Student Health Center. Insurance carried by the University may not cover costs of an injury. If I require medical attention as a result of my participation, I am responsible for any expenses.

The researcher is a nationally certified athletic trainer, state licensed athletic trainer, and is trained in CPR/AED and First Aid. He will be able to offer treatment if necessary, and will be present during each visit.

III. Benefits and Compensation

Benefits of participation in this test include receiving an evaluation of my 1RM values for the chest press exercise and an opportunity to learn firsthand about the process of data collection in a thesis-level research study. Reward for my time will be given as credit of attendance for two class periods in my PFW course at Texas State University.

IV. Privacy and use of information

All information gathered from this study will be kept private and will not be given to any person without my permission. All research materials will be kept in a locked cabinet for two years, after which they will be destroyed. The consent and demographics forms, linking my identity with the code number used on all other study materials, will be stored separately in the same way. I agree to the use of any data for research purposes as long as it does not provide facts that could lead to my identification.

V. Inquiries and Freedom of Consent

Participation in this research project is voluntary. If I choose not to participate, I will not receive any reward. I may choose to stop participating at any time.

If I have any questions about the research, my rights, or research-related injuries, I can contact the IRB chair, Dr. Jon Lasser (512-245-3413 – lasser@txstate.edu), or Ms. Becky Northcut, Compliance Specialist (512-245-2102).

I agree that I have read this document in its entirety or that it has been read to me.

I agree to participate in all procedures as explained in this form.

______________________________ Date __________
Participant's signature

______________________________ Date __________
Project Supervisor's Signature

____
IRB Approval #

APPENDIX 2

CODE #:____________________

HEALTH HISTORY QUESTIONNAIRE

Section A

1. When was the last time you had a physical examination?

2. If you are allergic to any medications, foods, or other substances, please name them.

3. If you have been told that you have any chronic or serious illnesses, please list them.

4. Give the following information pertaining to the last three times you have been hospitalized.

	Hospitalization 1	Hospitalization 2	Hospitalization 3
Reason for hospitalization			
Month and year of hospitalization			
Hospital			

Section B

During the past 12 months...

1. Has a physician prescribed any form of medication for you? Yes__No__

2. Has your weight fluctuated more than a few pounds? Yes__No__

3. If yes, did you attempt to bring about this weight change through diet or exercise? Yes__No__

4. Have you experienced any faintness, light-headedness, or blackouts? Yes__No__

5. Have you occasionally had trouble sleeping? Yes__No__

6. Have you experienced any blurred vision? Yes__No__

7. Have you had any severe headaches? Yes__No__

8. Have you felt unusually nervous or anxious for no apparent reason? Yes__No__

9. Have you experienced unusual heartbeats such as skipped beats or palpitations? Yes__No__

10. Have you experienced periods in which your heart felt as though it were racing for no apparent reason? Yes__No__

At present...

1. Do you experience shortness or loss of breath while walking/running? Yes__No__

2. Do you experience sudden tingling, numbness, or loss of feeling in your arms, hands, legs, feet, or face? Yes__No__

3. Do you get pains or cramps in your legs? Yes__No__

4. Do you experience any pain or discomfort in your chest? Yes__No__

5. Do you experience any pressure or heaviness in your chest? Yes__No__

6. Have you ever been told that your blood pressure was abnormal? Yes__No__

7. Do you have diabetes? Yes__No__

If yes, how is it controlled? (Check One)

__Dietary means __Insulin injection __Oral medication __Uncontrolled

8. How often would you characterize your stress level as being high? (Check One)

__Occasionally __Frequently __Constantly

9. Have you ever been told that you have any of the following illnesses? (Check applicable)

__Myocardial infarction
__Coronary thrombosis
__Coronary occlusion
__Heart block
__Heart arrhythmia
__Arteriosclerosis
__Rheumatic heart
__Heart failure
__Aneurysm
__Heart disease
__Heart Attack
__Heart murmur
__Angina

Section C

1. Participants must be physically active, healthy, between 18 and 30 years of age, and with at least 3 years of resistance training experience, and at least 1 year of experience with resistance training on unstable platforms.

Do you meet these study inclusion criteria? Yes__No__

2. If not, which criteria in #1, above, does not apply to you:

____

____

3. Individuals will not be able to participate for the following reasons: smoking, obesity, a history of known cardiac, respiratory or metabolic disease, a history of physical injuries that would limit exercise ability, suffering from or taking medicine for a major physical or mental illness, or a history of shoulder pain or surgery.

Do any of the criteria in the list apply to you? Yes__No__

4. If yes, please specify which criteria in #3, above:

____

____

____

APPENDIX 3

CODE #:____________________

DEMOGRAPHIC INFORMATION

Name (Last, First, MI) ____

Date of Birth ____________________ Sex (M or F) ______________

Height ____________________ Weight _____________

Home Phone (___________)____________________________________

Work Phone (___________)____________________________________

Address ____

City/State/Zip ____

Family Physician ____

APPENDIX 4

DISABILITIES OF THE ARM, SHOULDER AND HAND (DASH) SCALE

Code #: ☐

Please rate your ability to do the following activities in the last week by entering the number corresponding the appropriate response into the Entry Field.

Activity	**No Difficulty**	**Mild Difficulty**	**Moderate Difficulty**	**Severe Difficulty**	**Unable**	**Entry**
1. Open a tight or new jar.	**0**	**1**	**2**	**3**	**4**	
2. Write.	**0**	**1**	**2**	**3**	**4**	
3. Turn a key.	**0**	**1**	**2**	**3**	**4**	
4. Prepare a meal.	**0**	**1**	**2**	**3**	**4**	
5. Push open a heavy door.	**0**	**1**	**2**	**3**	**4**	
6. Place an object on a shelf above your head.	**0**	**1**	**2**	**3**	**4**	
7. Do heavy household chores (e.g., wash walls, wash floors).	**0**	**1**	**2**	**3**	**4**	
8. Garden or do yard work.	**0**	**1**	**2**	**3**	**4**	
9. Make a bed.	**0**	**1**	**2**	**3**	**4**	
10. Carry a shopping bag or briefcase.	**0**	**1**	**2**	**3**	**4**	
11. Carry a heavy object (over 10 lbs).	**0**	**1**	**2**	**3**	**4**	
12. Change a lightbulb overhead.	**0**	**1**	**2**	**3**	**4**	
13. Wash or blow dry your hair.	**0**	**1**	**2**	**3**	**4**	
14. Wash your back.	**0**	**1**	**2**	**3**	**4**	
15. Put on a pullover sweater.	**0**	**1**	**2**	**3**	**4**	
16. Use a knife to cut food.	**0**	**1**	**2**	**3**	**4**	
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	**0**	**1**	**2**	**3**	**4**	

18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	**0**	**1**	**2**	**3**	**4**	
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	**0**	**1**	**2**	**3**	**4**	
20. Manage transportation needs (getting from one place to another).	**0**	**1**	**2**	**3**	**4**	
21. Sexual activities.	**0**	**1**	**2**	**3**	**4**	
Question	**Not At All**	**Slightly**	**Moderately**	**Quite A Bit**	**Extremely**	**Entry**
22. During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	**0**	**1**	**2**	**3**	**4**	
Question	**Not Limited At All**	**Slightly Limited**	**Moderately Limited**	**Very Limited**	**Unable**	**Entry**
23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	**0**	**1**	**2**	**3**	**4**	

Please rate the severity of the following symptoms in the last week.

Question	**None**	**Mild**	**Moderate**	**Severe**	**Extreme**	**Entry**
24. Arm, shoulder or hand pain.	**0**	**1**	**2**	**3**	**4**	
25. Arm, shoulder or hand pain when you performed any specific activity.	**0**	**1**	**2**	**3**	**4**	
26. Tingling (pins and needles) in your arm, shoulder or hand.	**0**	**1**	**2**	**3**	**4**	
27. Weakness in your arm, shoulder or hand.	**0**	**1**	**2**	**3**	**4**	
28. Stiffness in your arm, shoulder or hand.	**0**	**1**	**2**	**3**	**4**	
Question	**No Difficulty**	**Mild Difficulty**	**Moderate Difficulty**	**Severe Difficulty**	**So Much Difficulty That I Can't Sleep**	**Entry**
29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand?	**0**	**1**	**2**	**3**	**4**	

Question	**Strongly Disagree**	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**	**Entry**
30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem.	**0**	**1**	**2**	**3**	**4**	

A DASH score many not be calculated if there are greater than 3 missing items.	**DASH Score**	

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VITA

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