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Effects of the JAQBLOQ Forearm and Straight Arm Plank on Core Muscle Activation

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EFFECTS OF THE JAQBLOQ, FOREARM AND STRAIGHT ARM PLANK ON CORE MUSCLE ACTIVATION

by

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ABSTRACT

EFFECTS OF THE JAQBLOQ, STRAIGHT ARM AND FOREARM PLANK ON CORE MUSCLE ACTIVATION

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Old Dominion University, 2015
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Performing a plank has various benefits for all fitness levels. There are several different types of planks that can be performed, with or without equipment: straight arm, forearm and side plank. When one has a shoulder or arm injury, he or she will not be able to safely perform a plank. A piece of fitness equipment was recently designed to aid people with injuries so they can still perform a plank; the JAQBLOQ. It is a 12x13x14" high density EVA foam block used to assist one during a plank where the participant rests his or her chest on it.

This study examined the difference between EMG muscle activation in the anterior deltoid, rectus abdominus and external oblique during the JAQBLOQ plank, forearm plank, and straight arm plank.

There were 20 participants recruited for this study; 10 men and 10 women. One subject was excluded for his or her inability to complete the required tasks. Participants that were physically active with no shoulder injuries in the past six months, no cosmetic surgery in the past year, no orthopedic shoulder, back or neck surgery, and not currently pregnant, were recruited for the study. Participants were recruited based on a BMI less

than or equal to 25 kg·m^{-2}. They were instructed to hold each plank for 30 seconds with a five-minute rest in between.

Results showed that during testing, participants' anterior deltoid produced activations of 4.1±7.2% maximal voluntary isometric contraction (MVIC) for JAQBLOQ, 39.1±23.8% MVIC for straight arm, and 42.0±20.9% MVIC for forearm. There was higher average muscle activation in the rectus abdominis during the forearm 30.2 ± 26.0 as opposed to straight arm 20.1 ± 16.7 and JAQBLOQ 5.3 ± 4.3. There was higher average muscle activation in the external obliques during forearm 29.7 ± 14.0 as opposed to straight arm 22.2 ± 12.5 and JAQBLOQ 17.7 ± 15.9. There was a significant difference ($p<0.001$) in EMG activity during the planks. The JAQBLOQ plank had significantly less EMG activity than the straight arm plank. The JAQBLOQ plank had significantly less EMG activity than the forearm plank. The straight arm plank had significantly less EMG activity than the forearm plank.

The greater activation of the deltoid during the straight arm and forearm planks compared to the JAQBLOQ plank demonstrates that the JAQBLOQ was successful in greatly reducing the effort required by the shoulders. Regarding abdominal muscles, the JAQBLOQ plank reduced activation of the recuts abdominis while still eliciting good activation of the external obliques. In addition, there was higher muscle activation in the abdominals and deltoid during the forearm plank in comparison to the JAQBLOQ plank and straight arm plank.

ACKNOWLEDGEMENTS

I would like to dedicate my Thesis to my family; Mother, Jeanetta Clark, and Tim Brown, Father, Ron Clark, and Wanda Sanders, sisters, Julie and Jennifer Clark, my grandparents Edna and the late Earl Reese and my better half, Michael Deering. Without the support of all of you, I wouldn't be where I am today. Thank you for the unconditional love and guidance. I would like to thank my committee members, Dr. Joshua Weinhandl, Dr. Swain and Dr. Laura Hill as well as my lab members, Zach Sievert, Kevin Fontenot and Lydia Haren who helped through each step of the way, it was much appreciated! I would also like thank Oneximo Gonzalez for being an amazing friend and providing me with top notch CAD drawings!

NOMENCLATURE

EMG	Electromyography
EO	External Oblique
RA	Rectus Abdominis
AD	Anterior Deltoid
MVIC	Maximal Voluntary Isometric Contraction

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Chapter 1: Development of the Problem

Background and Rationale

There are various exercises to help strengthen the core muscles in a plank position. Unfortunately, people who have shoulder injuries are usually unable to execute those exercises safely without any pain or exacerbating the injury (Escamilla, Yamashiro, Paulos & Andrews, 2012). The plank, one such exercise, is an isometric core exercise that is held for a period of time to help increase core strength. There are several muscle groups that are involved in the plank: rectus abdominis, internal and external oblique, iliopsoas, anterior, medial and posterior deltoid, transverse abdominis, erector spinae, trapezius, rhomboids, rotator cuff, latissimus dorsi, pectorals, gluteus maximus, quadriceps and gastrocnemius. The plank not only activates the abdominals, obliques and muscles in the back, but it also engages the shoulders, specifically the anterior deltoids (Escamilla, Babb, DeWitt, Jew, Kelleher, Burnham, Busch, D'Anna, Mowbray & Imamura, 2006).

A previous study examined the level of muscle activation in various core muscles during an isometric prone exercise (Snarr & Esco, 2014). Research has shown the effectiveness of planks versus other abdominal exercises (Parkhouse & Ball, 2010). One study recorded muscle activation during a plank exercise in comparison with various core exercises (Maeo, Takahashi, Takai, & Kanehisa, 2013). The results showed that abdominal bracing is one of the most effective techniques for inducing higher muscle activation in the internal obliques in comparison to other abdominal exercises involving torso flexion/extension. The plank was found to be the most effective abdominal core exercise (Maeo et al., 2013).

The JAQBLOQ is a high density foam block that is 2 lb per cubic foot and 12x13x14". It was originally designed for people who have shoulder injuries. After personal training clients for 11 years and having to avoid certain exercises for the clients with shoulder injuries, I realized that there was a need for a new type of fitness equipment. The JAQBLOQ is designed so the participant can rest his or her chest on the product while in a plank position, thereby taking weight off the shoulders and isolating the core muscles. This will theoretically allow him or her to hold a plank in addition to various other exercises with similar core muscle activation.

Statement of the Problem

Previous research studies have examined the level of muscle activation in various core muscles during an isometric plank position. However, shoulder injuries often impair plank performance and it remains unknown if similar core muscle activation can be attained while minimizing shoulder muscle activation through the use of an ergonomic aid. Furthermore, there has been no research to date on the effectiveness of one such aid, the JAQBLOQ, during a plank exercise.

Statement of Purpose

The purpose of this study is to compare the level of core and shoulder muscle activation in a straight arm plank and forearm plank to a plank on the JAQBLOQ using surface electromyography (EMG).

Research Hypotheses

Core muscle activation while utilizing the JAQBLOQ in a plank will show the same levels as a regular straight arm plank or a forearm plank. Muscle activation in the anterior deltoid will be less while performing a JAQBLOQ plank.

Independent Variables

- Prone Plank (Straight arm plank, forearm plank and JAQBLOQ plank)

Dependent Variables

- Average muscle activation levels in the rectus abdominis, external obliques and anterior deltoid.

Limitations of the Study

- An individual's prior activity level could influence the results; e.g., if it is low and he or she does not have the strength to perform a plank for 30 seconds.
- The order in which the three different planks are done; one with the JAQBLOQ, one straight arm plank and one on the forearms. Depending on which plank is done first the second plank readings could be skewed due to fatigue.
- The participants could be fatigued prior to being examined, even though they are asked not to perform any exercise the day of the study.
- Electrodes might not be placed exactly on the external obliques, rectus abdominis and anterior deltoid (EMG potential crosstalk from nearby muscles, distorted signals from innervation zone or musculotendinous electrode placements). Participants will perform movements to normalize the data and show proper muscle activation and electrode placement.

Delimitations of the Study

- The population of this study will consist of 20 active male and females between the age of 18 and 55 years.
- The study will exclude people with rotator cuff and or labrum tears in the last year.

Assumptions of the Study

- The surface EMG will be properly placed on the external oblique, rectus abdominis and anterior deltoid that will minimize crosstalk.
- The participants are going to properly execute the plank for 30 seconds during each test and will follow the researcher's protocol.
- All participants are going to answer the questions honestly on the assessment screening form.
- They will not be fatigued; there will be proper rest of 5 minutes in between each plank.

Significance of the Study

Having the ability to isolate the core without incorporating the shoulder muscles, while using the JAQBLOQ, will be highly beneficial for people with shoulder injuries. This study could not only change the personal training industry but it could also impact the physical therapy field. In addition, there will be a new variety of exercises for personal trainers and physical therapists to use with clients.

Operational Definition of Terms

Electromyography: Technique for measuring and recording electrical muscle activity.

Straight Arm Plank: Prone, isometric core exercise that is performed on the hands and toes.

Forearm Plank: Prone, isometric core exercise that is performed on the forearms and toes.

JAQBLOQ: High density EVA foam block, 12x13x14", which can be utilized by people that have shoulder injuries.

JAQBLOQ Plank: Prone, isometric core exercise that is performed on the toes with the chest resting on the JAQBLOQ and hands resting on the floor.

Crosstalk: Recording of EMG signals from adjacent muscles.

Innervation Zone: The distribution or supply of nerves to a certain area.

Musculotendinous Junction: Area where the muscle and tendon are joined.

Chapter 2: Review of the Literature

Introduction

A traditional front, straight arm plank and forearm plank are bodyweight exercises that are designed to increase core strength to help prevent injuries. The core consists of the musculature of the pelvis and trunk that are responsible for the stability of the spinal column (Snarr & Esco, 2014). There are various muscles that are activated during a straight arm plank: rectus abdominis, internal and external oblique, iliopsoas, anterior, medial and posterior deltoid, transverse abdominis, erector spinae, trapezius, rhomboids, rotator cuff, latissimus dorsi, pectorals, gluteus maximus, quadriceps and gastrocnemius.

Previous research has demonstrated that planks are effective in increasing core strength and stabilization (Snarr & Esco, 2014). There is a lot of research involving devices that create instability to increase core muscle activation (Snarr & Esco. 2014). It is beneficial to train individuals in an unstable environment but one needs to have a strong muscular foundation in order to progress to exercising with instability. Generally, previous research has shown that exercises that challenge stability also increase core muscle activation (Snarr & Esco, 2014). On the contrary, there has not been a lot of research on core muscle activation with devices that create stability. The JAQBLOQ was created to help individuals receive the same benefits of doing a plank without utilizing the shoulder muscles. Individuals rest their chest on the high density foam block in order to deactivate their shoulder stabilizers. Individuals that have a shoulder injury might not be able to hold themselves in a plank position safely and without pain (Escamilla et al., 2012). In addition, there are various exercises that they are unable to do because they cannot hold themselves in a prone position.

Anatomy of the Core

The major muscles that move, support and stabilize one's spine are referred to as the core or trunk (Delaney, 2014). The core is comprised of the rectus abdominis, internal and external obliques, transverse abdominis, erector spinae and multifidi, just to name few. These muscles provide stability for the spine, allow for flexion, rotation and side bending (Oliver, Dwelly, Sarantis, Helmer & Bonacci, 2010). They also provide protection for the abdominal organs.

The rectus abdominis (RA) provides stability and trunk mobility. The RA is part of the xiphoid process and adjacent costal cartilages (Brumitt, 2010). It attaches distally into the pubic bone at the crest and symphysis. This muscle is a prime mover during a basic crunch and provides support during a plank (Marieb, Mallatt & Wilhelm, 2004).

The transverse abdominis (TA) is the most inner muscle in the core. It originates from the lower six costal cartilages, the thoracolumbar fascia, and the iliac crest. This muscle attaches medially at the linea alba. The TA plays a key role in core stabilization especially during rehab (Brumitt, 2010).

The internal and external obliques provide trunk rotation and bending. They also provide stability to the spine. The external oblique is the most superficial muscle of the obliques (Marieb et al., 2004). The external oblique arises from the front lateral portion of the lower seven ribs, and it inserts into the linea alba, the pubic tubercle, and the anterior portion of the iliac crest. The internal oblique originates from the thoracolumbar fascia, the inguinal ligament, and the anterior iliac crest (Brumitt, 2010).

The core also includes the muscles in the erector spinae: longissimus, spinalis, multifidi and illocostalis. The erector spinae assists in extension of the trunk. It also allows the torso to bend to the side. The multifidi provides stability and support to the spine (Delaney, 2014).

Anatomy of the Shoulder

The shoulder is the most mobile joint in the body. The shoulder allows for rotation of the arm in a circular motion as well as lateral, frontal and overhead elevation. The shoulder joint is a ball-and-socket joint formed by the head of the humerus glenoid cavity of the scapula (Tortora & Derrickson, 2011). These two parts work together to allow the arm to rotate circularly. It is surrounded by soft tissue and strengthened by fibrous ligaments that help prevent dislocations. A ring of cartilage known as the labrum surrounds the glenoid fossa to extend the size of the socket while maintaining flexibility.

The rotator cuff is comprised of several muscles and tendons. The four muscles of the rotator cuff extend from the scapula and surround the head of the humerus to both rotate the arm and prevent dislocation. The supraspinatus, infraspinatus, teres minor and subscapularis join the scapula to the humerus (Tortora & Derrickson 2011). The rotator cuff muscles hold the head of the humerus in the glenoid cavity. The supraspinatus muscle is important in maintaining dynamic stability of the shoulder and is commonly injured. The rotator cuff assists in glenohumeral abduction, external rotation and internal rotation (Escamilla et al., 2006). Planks help strengthen the supraspinatus and play an integral role in rehabilitation from shoulder injuries (Malanga, Jenp, Growney & An, 1996).

The acromioclavicular joint is formed by the clavicle and the scapula. The function of the joint is for gliding and rotation of scapula on the clavicle (Marieb et al., 2004). It is a flat, gliding joint that gives the shoulder joint additional flexibility and allows for the arm to raise overhead.

Most of the stability and strength of the shoulder is provided by the rotator cuff muscles and ligaments as well as the three deltoid muscles (anterior, medial and posterior). The anterior deltoid assists in forward arm flexion and abduction (Escamilla et al., 2006). Performing planks can help increase stability and strength in the shoulders but conversely shoulder injuries can prevent one from being able to safely hold a plank for extended periods of time.

Biomechanics of the Straight Arm Plank

A plank is a static hold that targets various muscle groups. The straight arm plank is the product of a resisted closed-kinematic chain bilateral protraction of shoulders and resisted closed-kinematic chain bilateral hip flexion. Full extension of the upper and lower extremities is maintained by the extensor muscles at the elbow (triceps) and knee (quadriceps) joints of all four extremities (Rajkumar, 2010). The humeral head and medial end of the clavicles assist with lifting the upper trunk. During the straight arm plank, the distance between the xiphoid process and the pubic symphysis must be kept neutral during the entire isolated hold. In addition, the pelvis has to be lifted, which is a result of bilateral hip flexion while pressing the toes into the ground (Rajkumar, 2010). To execute the plank, the iliacus and psoas major are the agonists of hip flexion, which lifts the pelvis using the femoral heads (in this posture, closed-kinematic chain hip flexion will result in the femoral head going upward instead of femoral condyles moving downward) (Rajkumar, 2010). These hip flexion agonists are reinforced by the quadriceps which keep the knee extended, so the lower extremity can participate in this pelvis lifting maneuver (Rajkumar, 2010). During this isometric hold, the proximal attachment sites (iliac fossa & lumbar vertebrae) of hip flexion agonists must be stabilized to prevent anterior tilt of the pelvis and exaggerated lumbar lordosis (Rajkumar, 2010). The activation of the core abdominal muscles help stabilize the pelvis and lumbar vertebrae, ensuring the neutral distance between the xiphoid process and pubic symphysis and enabling the hip flexors to efficiently push the pelvis upwardly using femoral heads (Rajkumar, 2010). The plank is maintained by co-activation of the deltoids, triceps, pectorals, serratus anterior, psoas major, iliacus, erector spinae, rectus abdominis, internal and external obliques, transverse abdominis, gluteus maximus, quadriceps and gastrocnemius (Rajkumar, 2010). Increasing core muscular strength can significantly reduce the incidence of lower back injuries, increase performance or trunk stability (Snarr & Esco, 2014).

Electromyography

There are various studies that analyze muscle activity during a plank position (Caterisano et al, 2013). These studies show that a plank is an effective way for increasing core strength and activating the abdominals.

Lehman et al. (2005) looked at muscle activity during bridging exercises on and off a swiss ball. Eleven males were recruited for the study. They all had been doing weight training for at least six months prior and had no previous injuries or upper back pain. Each subject had to perform 5 different planks: Supine bridge, supine bridge on swiss ball, prone bridge (forearm plank), prone bridge on a swiss ball and a side bridge. Electrodes were placed on the rectus abdominus, external and internal obliques and lower erector spinae. The results showed more muscle activation in the rectus abdominus and external obliques during the prone bridge and the prone bridge with the stability ball than the other exercises. The prone bridge showed high muscle activity in the internal and external obliques and rectus abdominus but low activity in the erector spinae. The side bridge has the highest muscle activity in the internal oblique and erector spinae.

Ekstrom et al. (2007) looked at EMG core, hip and thigh muscle activity during 9 different rehabilitation exercises. There were 19 males and 11 females that performed all 9 exercises and EMG recordings were taken from the gluteus medius and maximus, internal and external obliques, rectus abdominus, lumbar multifidus, longissimus thoracis and hamstrings. One of the exercises performed was a prone bridge on the forearms. Participants were required to hold the prone bridge for 5 seconds, three sessions with a 30 second rest period. EMG activity for the prone bridge showed higher muscle activity in the gluteus medius, internal and external obliques and rectus abdominus than the lumbar multifidus, longissimus thoracis, gluteus maximus and hamstrings.

Although studies have shown the plank to be an effective abdominal exercise (Urquhart et al., 2005), Caterisano et al. (2009) looked at the plank in comparison to a basic crunch. The research showed more EMG core muscle activity in the upper rectus abdominus, lower rectus abdominus and EO during a basic crunch as opposed to the traditional plank. Snarr and Esco (2014) studied the abdominal muscle activation while using instability devices. They investigated the EMG activity of the RA, EO and erector spinae. Twenty men and women volunteered for the study and performed two isometric contractions of five different plank variations on their forearms, with or without an instability device. This study showed more muscle activation while performing a plank with an instability device.

Parkhouse and Ball (2010) looked at the influence of static versus dynamic core exercises on athletic performance. This study lasted six weeks in duration with two groups performing exercises for 45 minutes, twice a week. One group performed dynamic core exercises and the other performed static core exercises, which included the plank. Their findings showed that static prone exercises had greater effects on athletic performance versus dynamic performance (Parkhouse & Ball, 2010).

Conclusion

There are many benefits of performing a plank with and without an unstable surface. Snarr and Esco (2014) explained that planks performed with instability devices increases electromyographic activity in the superficial musculature when compared to traditional planks. Performing planks with an instability device is great for people without shoulder injuries. Because of the shoulder requirements during a plank, it can be challenging for people with shoulder injuries to hold a plank and should be avoided until clearance from a physician (Etheridge, 2013). The JAQBLOQ may allow an individual with shoulder injuries to perform a plank. A plank utilizing the JAQBLOQ may create the same amount of muscle activation in the core as a traditional straight arm plank, allowing people with shoulder injuries to get the same benefits as performing a traditional plank.

Chapter 3: Methods

Subjects

There were 20 participants recruited for this study; 10 men and 10 women, ages ranging from 19-29 yr, with an average age of 22.2 ± 3.0 yr, average height of 1.72 ± 0.09 meters, average mass of 68.1 ± 12.0 kg, and average BMI of 23.1 ± 2.2 $kg \cdot m^{-2}$. One subject was excluded for his inability to complete the required tasks. Participants that were physically active with no shoulder injuries in the past six months, no cosmetic surgery in the past year, no orthopedic shoulder, back or neck surgery, and not pregnant, were recruited for the study. Physically active was be defined as engaging in physical activity of at least a moderate intensity for a minimum of three times a week, 30 minutes per workout session. Moderate intensity was defined as participating in some type of physical exercise that is not exhausting for more than 15 minutes: fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing. That intensity level is in accordance with the Godin Leisure-Time Exercise Questionnaire. Participants were required to have a fitness level that allows them to easily hold a plank for at least 30 seconds. They signed a consent form stating that they have done a plank in the past and can hold it for at least one minute. Participants were recruited based on a BMI less than or equal to 25 $kg \cdot m^{-2}$. Prior to data collection, research approval from the Institutional Review Board of Old Dominion University and written informed consent from all subjects was obtained.

Experimental Protocol

Written consent (Appendix A), a health history form (Appendix B), and Godin Leisure-Time Exercise Questionnaire (Appendix C) were obtained from each subject.

The health history form and activity level questionnaire ensured all subjects met each of the inclusionary requirements to participate. The questionnaire was used to evaluate each subject for activity level, prior injuries, surgeries, and any medical condition that would affect his or her ability to participate in the study. Each female subject was required to wear a sports bra and low rise shorts/pants (do not go above the umbilicus). Each male was required to wear low rise shorts/pants and no shirt. Testing protocol was done in one day with five minutes of rest time in between the three, 30-second planks.

All testing was completed in the Neuromechanics Laboratory (ODU, Norfolk, VA, USA). Once the subjects were in proper testing attire, they were prepped for proper EMG placement. Each muscle electrode site was located by manual muscle testing on the left side of his or her body. All measurements will be taken on the left side of his or her body. The area was shaved (if necessary), lightly abraded, and cleaned with an alcohol pad. The EMG electrode was placed so that the electrode leads were perpendicular or parallel to the muscle fibers. EMG electrodes were placed on the EO, RA and AD. The RA had one electrode placed on the muscle, two cm lateral from the umbilicus on the left side of the participant. The EO had one electrode placed running parallel to the muscle fibers, lateral to the rectus abdominis, directly above the anterior superior iliac spine, half-way between the crest and the ribs. The AD had one electrode placed on the anterior aspect of the arm, approximately 4 cm below the clavicle running parallel to the muscle (Criswell, 2011). To ensure proper electrode placement, participants were required to do a standing straight arm front raise to elicit muscle activation in the AD. They were required to perform a standing forward flexion to elicit activation in the RA and a standing side bend to show activation in the EO. Once the electrodes were properly placed on the desired muscles, they were secured with pre wrap (Mueller Sports Medicine, Prairie du sac, WI) and athletic tape (Collins Sports Medicine, Raynham, MA).

Participants were then required to perform maximum voluntary isometric contractions (MVIC). Participants were asked to perform a straight arm front raise pressing on the underside of a table that was 0.8 meters high for five seconds. Then they were asked to perform a standard hands to heel crunch lying on their back with knees bent, holding for five seconds. Lastly, they were asked to do a standard left side oblique crunch lying on their back. They reached their left hand towards their left heel, holding for five seconds. During these three different types of exercises, participants were coached to perform them at maximal effort.

Participants either started with the straight arm plank (Figure 1), the forearm plank (Figure 2), or the JAQBLOQ plank (Figure 3). Participants were separated in to groups of five or less. They performed the same type of plank at the same time, in the same order. The plank orders were randomized for each group. Five people performed the JAQBLOQ plank first, the forearm plank second and the straight arm last. Another group of five performed the forearm plank first, the JAQBLOQ second and the straight arm last. Another group of five performed the straight arm first, the forearm second and the JAQBLOQ last. Another group of three performed the forearm first, the straight arm second and the JAQBLOQ last. A group of two performed the JAQBLOQ first, the straight arm second and the forearm last. The last participant performed the straight arm first, the JAQBLOQ second and the forearm last. Participants were shown how to hold each type of plank. Participants were shown how to hold a plank utilizing the

JAQBLOQ. Participants were required to lean their chest on the JAQBLOQ with the top of their shoulders in line with the front side of the JAQBLOQ. All participants put their chest on the side that is 12x14 inches and 13 inches high. They were instructed not to put any weight on their arms so the AD should be deactivated. Then the participants were shown how to perform a forearm plank. Their elbows were directly under their shoulders with the palms facing down on the floor. Their body was in a straight line with only their toes touching the floor and feet together. Lastly, the participants were shown how to hold a proper straight arm plank with their hands directly under their shoulders. They were instructed to hold each plank for 30 seconds. During this time, participants did not receive instruction or encouragement. Once each plank was completed participants rested with no activity for five minutes.

The researcher was blinded to the condition order and only allowed to prep the subjects. The researcher's aide was responsible for collection of the data and randomization of the subjects. Data remained blinded until after statistics were run.

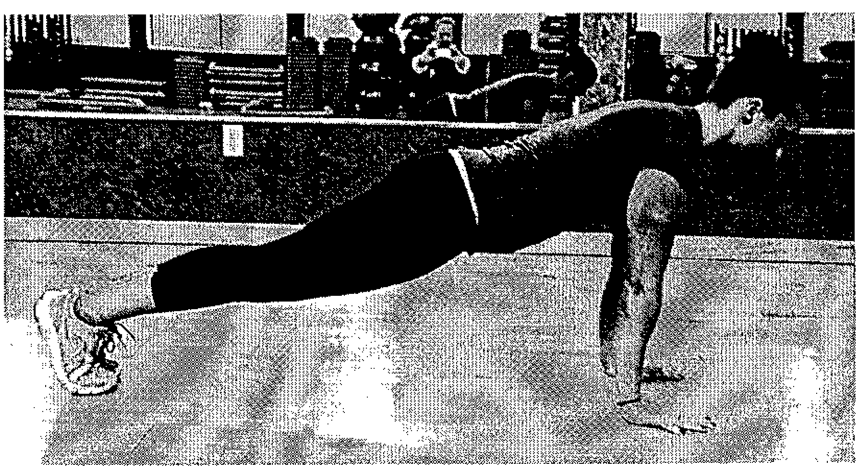

Figure 1. Straight arm plank

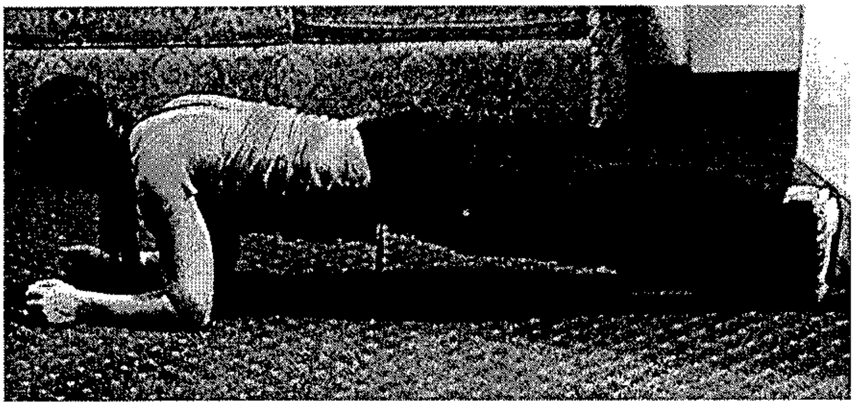
Figure 2. Forearm plank.

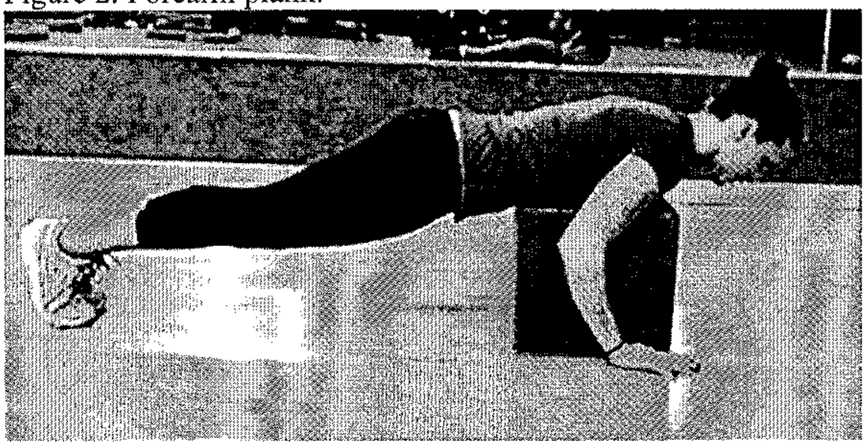
Figure 3. JAQBLOQ plank

Instrumentation

All EMG data were collected at 2000 Hz using a Trigno 16 channel wireless surface electrode electromagnetic system (Delsys Inc. Boston, MA). EMG electrodes were single differential, pre-amplified, composed of 99.9% silver, and had a contact area of 5 mm^2.

Data Reduction & Analysis

Data were reduced with a custom MatLab program (MathWorks, Natick, MA). First, DC bias was removed. Signal content was then high-pass filtered with a cut off frequency of 10 Hz to eliminate movement artifact. Then the signal was full wave rectified resulting in a positive signal that was low-pass filtered with a frequency cut off of 5 Hz to create a linear envelope. Lastly, data were normalized to the MVIC representing a percentage of total activation for each muscle. The conditions were randomly coded during data analysis and reduction to prevent researcher bias.

Statistical Analysis

Average activation for each muscle was submitted through a 3-way repeated measures ANOVA. Post-hoc analysis was done to show a potential pairwise comparison between the means using Student-t tests with Bonferroni corrections. All statistical analyses was conducted using SPSS (v21.0, SPSS Inc., Chicago, IL) with alpha level $p<0.05$.

Chapter 4: Results

Results (Table 1) showed that the 3-way repeated measures ANOVA for the anterior deltoid had a $F(2,36)=40.16$, $p<0.001$. During testing, participants' anterior deltoid produced activations of 4.1±7.2% MVIC for JAQBLOQ, 39.1±23.8% MVIC for straight arm, and 42.0±20.9% MVIC for forearm. Post Hoc analysis revealed the pairwise comparisons between JAQBLOQ and straight arm, as well as JAQBLOQ and forearm were significantly different with $p<0.001$. There was no significant difference between straight arm and forearm with $p=0.431$.

Results showed that the 3-way repeated measures ANOVA for the rectus abdominis had a $F(2,36)=18.86$, $p<0.001$. During testing, participants' rectus abdominis produced activations of 5.3±4.3% MVIC for JAQBLOQ, 20.1±16.7% MVIC for straight arm, and 30.2±26.0% MVIC for forearm. Post Hoc analysis revealed the pairwise comparisons between JAQBLOQ and straight arm, as well as JAQBLOQ and forearm were significantly different with $p<0.001$. There was no significant difference between straight arm and forearm with $p=0.005$.

Results showed that the 3-way repeated measures ANOVA for the external oblique had a $F(2,36)=12.74$, $p<0.001$. During testing, participants' external oblique produced activations of 17.7±15.9% MVIC for JAQBLOQ, 22.2±12.5% MVIC for straight arm, and 29.7±14.0% MVIC for forearm. Post Hoc analysis revealed the pairwise comparisons between JAQBLOQ and forearm, as well as straight arm and forearm were significantly different with $p<0.001$. There was no significant difference between JAQBLOQ and straight arm with $p=0.170$.

Table 1. Mean ± standard deviation EMG activity (%MVIC) of the rectus abdominis (RA), external oblique (EO) and anterior deltoid (AD).

	JAQBLOQ Plank	Straight Arm Plank	Forearm Plank
RA[*abc]	5.3 ± 4.3	20.1 ± 16.7	30.2 ± 26.0
EO[*bc]	17.7 ± 15.9	22.2 ± 12.5	29.7 ± 14.0
AD[*ab]	4.1 ± 7.2	39.1 ± 23.8	42.0 ± 20.9

*There was a significant difference ($p<0.001$) in EMG activity during the planks.
[a] JAQBLOQ plank had significantly less EMG activity than the straight arm plank.
[b] JAQBLOQ plank had significantly less EMG activity than the forearm plank.
[c] Straight arm plank had significantly less EMG activity than the forearm plank.

Chapter 5: Discussion

The objective for this study was to determine the level of muscle activation in the anterior deltoid, rectus abdominis and the external oblique during a straight arm plank, forearm plank and a JAQBLOQ plank. Subjects were asked to perform three different types of planks. It was hypothesized that: 1) there would be similar muscle activation in the external oblique and rectus abdominis during a JAQBLOQ plank in comparison to the forearm and straight arm plank; 2) there would be lower activation in the anterior deltoid during the JAQBLOQ plank.

Contrary to the first hypothesis, muscle activation was significantly less in the recuts abdominis during the JAQBLOQ plank than either of the other planks. Also, activation of the external oblique was significantly less during the JAQBLOQ plank than the forearm plank. In conjunction with the first hypothesis, it was similar between the JAQBLOQ and straight arm planks (numerically, but not statistically, lower during JAQBLOQ). As expected in the second hypothesis, activation of the anterior deltoid was greatly reduced during the JAQBLOQ plank as compared to the other two. JAQBLOQ had the lowest EMG activations for all three muscles, anterior deltoid, rectus abdominis and external oblique. Straight arm had the second highest EMG activations for all three muscle groups. Forearm had the highest EMG activation for all three muscles.

The higher muscle activation in the forearm plank could be due to the angle of the body in relation to the floor. As the angle of the body relative to the floor increases, the torque created by the person's body weight above the pelvis decreases. Torque is defined as the rotational effect of an eccentric (off axis) force and is mathematically determined as the product of the force magnitude and the force moment arm. The force magnitude is unaffected by body angle as body weight does not change. However, the force moment arm (perpendicular distance from the axis of rotation to the line of action of the force) decreases as the body angle increases; thus decreasing the torque. Since the external torque created by the person's body weight decreases with increasing body angle, the principles of static equilibrium dictate that the internal torque produced by the core muscles must decrease accordingly. With a decreased torque demand placed on the core muscles with increasing body angle, there will be a corresponding decrease in muscle activation. This basic mechanical concept of torque and static equilibrium explains the reduced muscle activation exhibited in straight arm planks relative to forearm planks and partially explains the reduction in muscle activation seen in JAQBLOQ planks relative to forearm planks. It does not, however, explain the reduced activation in JAQBLOQ planks relative to straight arm planks. Therefore, there needs to be more research on JAQBLOQ's of varying dimensions as well.

The reduced activations seen in the JAQBLOQ could also be explained by the amount of support provided by the JAQBLOQ. A plank is essentially a bridge with two support beams, the feet and the arms. The bending moment (torque) is a function of the body weight and distance from the supports to the bending point (hips). When comparing the straight arm and forearm planks the supports are in the same location and the torque demands on the musculature are primarily dependent on body angle, as previously explained. In the JAQBLOQ plank, the upper body base of support is longer (encompassing shoulders to lower chest) and decreases the distance to the bending point, i.e., the distance from support to the bending point is from lower chest to hips in the JAQBLOQ plank, but this distance is from shoulders to hips in the forearm and straight arm planks. This creates a substantially more stable "bridge," decreasing the bending moment and corresponding internal torque demands on the core muscles. Therefore, it is plausible that a JAQBLOQ with a narrower top, such as a trapezoidal rather than a rectangular shape, would elicit greater core muscle activation while still providing the support necessary to reduce anterior deltoid muscle activation.

The reduced activations seen with the JAQBLOQ could also have been affected by the participants' focus. Simply cueing the participant to tighten their core could change the results. One research study showed that just cueing someone to posteriorly tilt their pelvis by "Breathe in and out; gently and slowly rock your pelvis backwards," will create greater muscle activation in the internal oblique and rectus abdominis (Urquhart et al., 2015). In addition, this study also examined when the participant was cued to brace his or her core by "Breathe in and out; gently and slowly swell out your waist without drawing your abdomen inwards or moving your back or pelvis." Results showed greater muscle activation in the external oblique.

The JAQBLOQ had lower muscle activations overall. Previous research has shown that the more stable the surface is for the plank, the lower the muscle activation. One study analyzed muscle activation in the internal oblique, external oblique, rectus abdominus, and erector spinae during a prone plank and a prone plank on a swiss ball. The results showed greater muscle activation in all muscles during the prone plank on the swiss ball (Lehman et al., 2005).

The hypothesis of this study was that the JAQBLOQ would reduce anterior deltoid activation while maintaining core muscle activation. The results partially support this hypothesis since the anterior deltoid muscle activation was lower but the core muscle activation was also significantly lower than the forearm and straight arm planks. The JAQBLOQ is beneficial for those with shoulder injuries since it lowers activation in the anterior deltoid but the benefits of core muscle activation are limited. More research needs to be done on modifications to the JAQBLOQ that might increase core muscle activation.

Previous research validates the current findings in this study. One study looking at EMG muscle activation during a forearm plank showed higher activation in the rectus abdominis (32.7 ± 10.8% MVIC) than the external oblique (31.7 ± 8.5% MVIC) (Tong, Wu & Nie, 2014). This coincides with the results from this study for the forearm plank; rectus abdominis (30.2 ± 26.0% MVIC) and external oblique (29.7 ± 14.0 % MVIC). Another study showed greater muscle activation in the external oblique (0.78 ± 0.10% MVIC) than the rectus abdominis (0.23 ± 0.04% MVIC) during the straight arm plank (Ni et al., 2014), which confirms the results of greater muscle activation during the straight arm plank in the current study; rectus abdominis (20.1 ± 16.7% MVIC) and external oblique (22.2 ± 12.5% MVIC).

Although performing a plank on the JAQBLOQ decreased muscle activation in the anterior deltoid, it also decreased muscle activation in the rectus abdominis and external oblique. More research needs to be done on JAQBLOQs with different dimensions, as well as research while performing planks and verbally cueing participants to activate their core muscles. It is plausible that a JAQBLOQ that was of similar height as the body during a forearm plank would elicit greater muscle activation in the rectus abdominis and the external oblique.

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APPENDIX A: Informed Consent Document

Old Dominion University

PROJECT TITLE: Effects of the JAQBLOQ on Core Muscle Activation during a Straight Arm Plank

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INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. This project is being carried out to determine the effects of doing a JAQBLOQ plank on EMG activity of the core muscles. The JAQBLOQ is a patent pending high density foam block (12x13x14). This study will be testing the effectiveness of this new piece of equipment. The research will be conducted at Old Dominion University in the Neuromechanics Laboratory.

RESEARCHERS

Joshua Weinhandl, PhD, Responsible Project Investigator, Assistant Professor, Darden College of Education, Department of Human Movement Sciences, Old Dominion University

Jacquelyn Clark, Graduate Student, Department of Human Movement Sciences, Old Dominion University

Kevin Fontenot, PhD Student, Department of Human Movement Sciences, Old Dominion University

DESCRIPTION OF RESEARCH STUDY

The purpose of this study is to compare the EMG core muscle activity during a prone plank to a JAQBLOQ plank. You will report to the Neuromechanics Laboratory, SRC 1007, for one hour long testing session. You will be asked to perform two, one minute planks. One will be a straight arm prone plank. The other plank will be a JAQBLOQ plank, where you will rest your chest on the JAQBLOQ with your hands resting on the floor.

At the beginning of each testing session, prior to doing a plank, you will be asked to perform a sit-up, side crunch and a resisted front arm raise.

Data collection will consist of measurements of height and weight. Proper attire for the testing is required. For women, sports bra or tank top not covering the abdomen and shorts or pants that don't go higher than the naval. For men, no shirt and shorts or pants that don't go higher than the naval. EMG areas will be prepped and three EMG's will be placed on the anterior deltoid, external oblique and rectus abdominis. During the visit to the lab, you will be asked fill out a Medical History and Physical Activity Questionnaire. This includes questions pertaining to age, physical activity, upper body injury(ies), recent shoulder injury(ies), or any medications that may affect your ability to exercise.

EXCLUSIONARY CRITERIA

To be eligible to participate you must be physically active three days a week for at least 30 minutes and be able to hold a straight arm plank for at least one minute.

You will not be able to participate in the study if you:

- have suffered any injuries to the shoulders within the last six months
- have ever had orthopedic shoulder, back or neck surgery
- are pregnant or think you may be pregnant
- had cosmetic surgery in the last year
- have a BMI over 25
- have participated in physical activity the day of the study
- have eaten one hour prior to the study

RISKS AND BENEFITS

RISKS:
If you decide to participate in this study, then you may experience general muscle soreness and/or minor skin irritation due to the adhesive on the external markers. It is also possible, although unlikely, that you may experience musculoskeletal injury such as a muscle strain.

To reduce the above risks, care will be taken when applying and removing the EMG's. If you feel any soreness or irritation while participating in this study, please tell the investigators as soon as possible. The investigators will provide you with the appropriate information for treating these problems, based on our level of expertise. If you are injured while participating in this research study, you will initially be provided care by the investigator(s) and will then be referred to the Student Health Services (students) or your personal physician (non-students) for follow-up care.

There is a small risk of loss of confidentiality. To minimize this risk all information gathered from you will be confidential in nature and stored in the laboratory of the principle investigator (SRC 1007). Only the principal investigator and research personal will have access to these files.

BENEFITS:

There are no direct benefits from participating in this study. The information obtained in this study will expand our knowledge base leading to beneficial changes in the future.

COSTS AND PAYMENTS

The researchers are unable to give you any payment for participating in this study. Students in Exercise Science courses may be offered extra credit for participation per individual course policy. Total point value for participation will be determined by course instructor. Students in courses offering extra credit for research participation may receive extra credit of equal point value by completing an alternative assignment.

NEW INFORMATION

If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY

The researchers will provide confidentiality to all documents regarding patient information, including questionnaires and test results, by storing information in a safe, locked location. The results of this study may be used within reports, presentations or publication; but all personal identifiers will be disregarded. However, your records may be subpoenaed by court order or inspected by government bodies with oversight authority. Following the completion of the study, all subject information will be destroyed.

WITHDRAWAL PRIVILEGE

In the event that you no longer wish to participate, you have the right to discontinue participation for this study. Even if you initially wish to participate you can withdraw at any time. Your decision will not affect your relationship with Old Dominion University or cause a loss of benefits to which you might otherwise be entitled. In addition, the researcher has the right to withdraw your participation if they find potential problems with your continued participation.

COMPENSATION FOR ILLNESS AND INJURY

If you participate, then your consent in this document does not waive any of your legal rights. In the event that you are harmed or injured from participating in this study, neither Old Dominion University nor the researchers are able to give you any compensation, including money, insurance coverage, or free medical care. In the event that you suffer any injury from participation in this study, you may contact Dr. Joshua Weinhandl at (757) 683-4754, Dr. George Maihafer, the current IRB chair, at (757) 683-4520, or Office of Research (757) 683-3460 at Old Dominion University.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Joshua Weinhandl 757-683-4754

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. George Maihafer, the current IRB chair, at 757-683-4520, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

APPENDIX B: Medical History Questionnaire & Demographic Survey

Please answer the following questions to the best of your ability:

Gender: ☐Male ☐Female

Race/ethnicity *(please check all that apply)*:

☐American Indian/Alaska Native
☐Asian
☐Native Hawaiian or other Pacific Islander
☐Hispanic or Latino
☐Black or African American
☐White

To be completed by investigator:

Age:________ yr Height: ________ m Mass: ________ kg BMI: _______

<u>Medical History Questionnaire</u>

For your safety, a list of conditions that would make you unable to participate in this study has been prepared. Please read this list carefully and consider whether any of the conditions apply to you. If any of these conditions are true for you, you will not be able to participate in this study. For each condition, please indicate "yes" or "no" if this is true or not for you.

☐Yes ☐No Do you have a medical condition that may impair your ability to hold yourself in a prone plank position for at least one minute?

☐Yes ☐No Are you taking medications/drugs that may affect your ability to hold a plank?

☐Yes ☐No Have you <u>ever</u> had an upper extremity injury that caused you to decrease the amount of physical activity you undertake? If yes, please complete the following:

☐Yes ☐No Abdominal injury(ies)
If yes, approximately how many injuries?____________________________
☐Yes ☐No Back injury(ies)
If yes, approximately how many injuries? ____________________________
☐Yes ☐No Arm injury(ies)
If yes, approximately how many injuries? ____________________________
☐Yes ☐No Neck injury
If yes, approximately how many injuries? ____________________________

☐Yes ☐No Have you had, <u>in the last 6 months</u>, a shoulder injury that caused you to decrease the amount of physical activity you undertake?

☐Yes ☐No Do you <u>currently</u> have any shoulder pain or injury (ies)?

☐Yes ☐No Have you ever had major orthopedic surgery on either of your shoulders?

☐Yes ☐No Have you had any other surgery (ies) in the past year that would affect your ability to hold a plank?

☐Yes ☐No Are you pregnant or do you have reason to believe that you may be pregnant?

APPENDIX C: Godin Leisure-Time Exercise Questionnaire

1. During a typical **7-day period** (a week), how many times on average do you do the following kinds of exercise for **more than 15 minutes** during your free time (write on each line the appropriate number).

Times per week

   a. **STRENUOUS EXERCISE** (Heart Beats Rapidly) e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling ________

   b. **MODERATE EXERCISE** (Not Exhausting) e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing ________

   c. **MILD EXERCISE** (Minimal Effort) e.g., yoga archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking ________

2. During a typical **7-day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heart beats rapidly)?

OFTEN	SOMETIMES	NEVER/RARELY
☐	☐	☐

Curriculum Vitae

Jacquelyn Clark

CERTIFICATIONS:

- NASM CPT(Certified Personal Trainer)
- NASM CES(Corrective Exercise Specialist)
- NASM FNS(Fitness Nutrition Specialist)
- Penn State Certified Fitness Instructor
- Silver Sneakers MSROM & Cardio Circuit
- WaterArt (Water Fitness Certified)
- CPR/AED First Responder

EXPERIENCE:

TidalWheel **Virginia Beach, VA** **Oct 2012 – Present**
Lead Spin Instructor
- Instruct total body spinning class using weights and thera bands
- Train new instructors

TCC/Inlet Fitness **Virginia Beach, VA** **Feb 2015 – Present**
Instructor II / Fitness Instructor
- Instruct various fitness classes
- Small Group Training
- Program planning

City of Virginia Beach **Virginia Beach, VA** **March 2010 – Oct 2014**
Fitness Supervisor
- Supervise part-time fitness instructors and personal trainers
- Interview potential instructors and personal trainers
- Train new employees, interns and volunteers
- Work with current employees on improving their skills; instructor/trainer evaluations
- Coordinate meetings for personal trainers across 5 locations
- Plan, coordinate and instruct recreational programs and fitness classes
- Payroll
- Provide customer service
- Prepare monthly reports
- Member of the Inclusion and Diversity Board
- Manage outlook calendar; set up training sessions, meetings
- Design and implement health programs for clients
- Promote programs by attending meetings; Kiwanis, Advisory Board
- Collaborate with other departments to meet the customer needs

PSC / Onelife Fitness **PA/VA** **Feb 2007 – Oct 2012**
NASM Certified Personal Trainer & Fitness Instructor
- Design and implement health programs for clients
- Lead group exercise classes: Spin, Yoga, Pilates, Hi-low, Aqua, K-box, Step

Virginia Wesleyan **Norfolk, VA** **Fall 2011**
Fitness Director – Intern
- Designed a fitness program and ordered fitness equipment within budget
- Helped run monthly meetings
- Instructed a college wellness class and trained new instructors

Aerotek **Chesapeake, VA** **Feb 2008 – Aug 2009**
Technical Recruiter
- Conducted interviews, reference checks, client meetings
- Recruited potential candidates for engineering, professional and commercial industries
- Trained new internal employees on office practices and procedures
- Conducted and reviewed applicable pre-employment testing
- Organized and planned job fairs and special events
- Extended and terminated offers of employment based on performance
- Managed the process for all on-boarding duties; coordinated background checks offer packets, administered new hire paperwork and start dates
- Coached and trained candidates on interview techniques, resume writing and etiquette

Pennsylvania State University **State College, PA** **Aug 2002 – Dec 2006**
Fitness Instructor
- Led group exercise, organized fitness workshops

Aerobic Dance TA
- Instructed fitness classes, organized class plans

Math Tutor
- Taught math to college students, developed study strategies

Environmental Science TA
- Developed class plans, taught and led group discussions

AFFILIATIONS:
- **International Awareness Club (IAC)**
  Reporter for America's news; Delivered news for Penn State
- **Student Government Association (SGA)**
  Assistant Vice President; Planned and organized events and meetings
- **Council of Commonwealth Student Government (CCSG)**
  Student Affairs Director; Planned, organized and led committee meetings
- **Pennsylvania State University Athletics**
  Varsity Tennis

EDUCATION:
Old Dominion University **Norfolk, VA** **Aug 2015**
Masters; Exercise Science
Pennsylvania State University **State College, PA** **Dec 2006**
B.A. Psychology *Deans List