THE EFFECTS OF AN AQUATIC CORE TRAINING PROGRAM AND A PILATES CORE TRAINING PROGRAM ON CORE STRENGTHENING IN THE COLLEGE ATHLETE

THESIS

Submitted to the Faculty of the School of Graduate Studies and Research of California University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Science

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THESIS APPROVAL

Athletic Training

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"Strengthen the core" is the new buzz phrase in exercise and rehabilitation. In the past, training and rehabilitation programs focused on single and bi-planar motions. Research is beginning to address the concept of core strengthening in association not only with exercise training, but rehabilitation, and the prevention of injuries as well. The core is believed to be the center of gravity in which all movement begins. The main focus of core strengthening is muscular control required by specific musculature to maintain functional stability. The function of the core is to maintain optimal postural alignment before, during, and after activity. According to Manners and Scifers, core strength training allows individuals to develop an awareness of position of movement, as well as allowing muscles of the extremities to perform their functions without placing undue stress on the spine. In essence, "the core allows people to do more with less effort." 

The core is composed of 29 muscles that attach to the lumbo-pelvic-hip complex. These muscles are believed to be the center of gravity in which all movements begin. The core is based on the concept that all functional activities
are triplanar and require acceleration, deceleration, and dynamic stabilization. For optimal efficiency, it relies on normal working relationships between muscle length and tension of the functional agonists and antagonists. With this, the core allows for ideal force coupling within the lumbo-pelvic-hip complex.⁷

Muscle imbalances within body can be an inhibiting factor that can negatively affect the efficiency of the core. Early recognition and appropriate corrective measures are detrimental in maintaining optimal core efficiency. Posture is a key consideration in the evaluation of the core. Posture also functions to maintain proper spinal alignment and dynamic kinetics during functional activity. Optimal postural alignment and optimal dynamic kinetics rely on structural and functional efficiency, two major components of the core. Structural efficiency is the alignment of the musculoskeletal system, which allows posture to be balanced in relation to one’s center of gravity. Functional efficiency is the ability of the neuromuscular system to perform functional tasks with the least amount of energy and creates the least amount of stress on the kinetic chain.⁸ Therefore, a sufficient knowledge of the major components of the core and posture
are extremely valuable in the maintenance and training of the core.

Common core and postural distortions include upper crossed syndrome, lower crossed syndrome, and pronation distortion syndrome. Each of these distortions correlates to abnormal force coupling, decreasing neuromuscular efficiency, functional strength, and functional flexibility or some combination of the four. Core training can decrease the prevalence of these conditions, allowing for optimal performance.

While, land based exercise has been the method of choice in the past, aquatic and/or Pilates training can be used as a means of core strengthening as well. The physical properties and forces of water are the major factors in aquatic core training.

The physical properties of water include buoyancy, specific gravity, hydrostatic pressure, and viscosity. Buoyancy assists motion toward the surface of the water and resists motion moving away from the surface of the water, as stated in Archimedes Principle. This gives the athlete a sense of weightlessness while submerged, dramatically decreasing the compression stress on weight bearing joints, bones, and muscles. Specific gravity is the ratio of the mass of a given volume of substance to the mass of the same
volume of water. Depending on a person’s ratio of bone weight to muscle weight, the amount and distribution of fat, and the depth and expansion of the rib cage and chest cavity, specific gravity will determine each body part’s resistance to water and its ability to float.\(^{10}\) On average, humans have a specific gravity less than water; therefore, most will float. Hydrostatic pressure is the pressure exerted by any fluid on any body at rest. Hydrostatic pressure is equal to 14.7 pounds per square inch on the surface. However, for every one foot of depth added, hydrostatic pressure increases by .433 pounds per square inch.\(^{9}\) Therefore, while training, more resistance to movement is greater at the bottom of the pool or Swim-Ex\(^\text{®}\) than there is at the surface.\(^{11}\) Finally, viscosity is the type of resistance that occurs between the molecules of a liquid, determining its thickness and ability to flow.\(^{9}\) The higher the viscosity the greater the resistance. Water molecules adhere to the surface of a body moving through it, therefore water acts as resistance.

Other major contributors to aquatic therapy are the forces of water, cohesive force, bow force, and drag force. Cohesive force runs in a parallel direction to the water surface. The water molecules loosely bind together creating a surface tension and resistance.\(^{12}\) Bow force is
the force that is generated at the front of an object during movement. When an object is in motion in the water, pressure increases at the front of the object and decreases at the rear of the object. Finally, drag force is the resistance that occurs alongside an object, causing it to move slower through the water. Drag force is equal to two times the speed of the moving object against water flow or turbulent water. Water has 12 times more resistance than that of air. However, it is the relationship between the properties of water and the forces of water that require the core to work more efficiently to reduce and produce force and dynamically stabilize oneself while training in water.

Previous research in the area of core training has shown limitations. One limitation has been that because of the recent discovery of the theory of the core, current research has little evidence to help support new findings. Another limitation is that there has been meager research conducted on the types aquatic exercises that specifically effect the core. However, knowledge of the information previously discussed clarifies the need for research. Based on this knowledge, questions pertaining to the effectiveness of aquatic core training were generated: What are the differences between Aquatic Core Training and
Pilates Training and a control group for Plank Position scores? What are the differences between Aquatic Core Training and Pilates Training and a control group for Overhead squat scores? What are the differences between Aquatic Core Training and Pilates Training and a control group for Overhead medicine ball toss scores?
METHODS

The primary purpose of this study was to provide information regarding core strength training benefits provided by aquatic and Pilates training. Core strength and stability measurements were collected before and after an eight-week training program. The following are major section titles: Research Design, Subjects, Pilot Research, Instrumentation, Procedures, Hypotheses, and Data Analysis.

Research Design

This experiment followed the true experimental design. The independent variable is group assignment, to either an aquatics or Pilates core training program or a control group. The dependent variables were the scores for static, functional, and dynamic core strength and stability as measured by the plank position assessment test, the overhead squat assessment, and the overhead medicine ball toss assessment. Variable scores were defined by the researcher (Appendix C1,C2). Additionally, an inefficiency checklist (Appendix C1,C2), as defined by the researcher, was used for additional descriptive information. This was
a pretest/posttest design; therefore, subjects were evaluated before and after the five-week training session. Strengths of the design included the use of a control group for comparing pretest and posttest data results against the results produced by the aquatic and Pilates training groups. Potential limitations of the study were the generalizability of our results to the athletic population, and dedication of the subjects for the duration of the training and study.

Subjects

The subjects involved in this study included NCAA Division II male football players from California University of Pennsylvania. A convenience sample of approximately 30 volunteers from the football team were assigned to one of three research groups: Aquatic Core Training, Pilates Core Training, or a Control Group. Each subject was provided with an Informed Consent Form (Appendix C3) before taking part in the study. All identities remained confidential and are not included in the research study.
Preliminary Research

Due to the lack of previous research regarding aquatic core training one had to be constructed through trial and error. Two college male athletes, free of any pre-existing conditions, who do not currently participate in NCAA athletics, were tested as representatives of the desired sample. The two students were asked to perform seven entry-level aquatic core training exercises (Appendix C4), as defined by the researcher. Each exercise lasted one minute. The aquatic core exercises were as follows: stork standing on each leg (eyes closed), alternating jumping lunges, single leg plyoball toss, trunk twists, tuck jumps, single leg shoulder sweeps, and high knee running. The study aided the researcher in the organization for the most appropriate sequence of exercises to minimize fatigue and decrease time per training session. Safety measures were also extracted from these pilot training sessions, such as positioning the Swim-ex® aqua tank water current intensity remote closer to the researcher in case of emergency.
Instrumentation

A plank position, overhead squat, and overhead medicine ball toss assessment along with a demographic questionnaire are instruments which were used to measure static, functional, and dynamic core strength and stability. These tests are under research review for validity and reliability in assessing core stability and strength. Additionally, a postural analysis was conducted and evaluated by a grading scale (Appendix C5), as defined by the researcher. The Swim-Ex® Aquatic Therapy Tank and aquatic tools such as plyoballs™, aqua gloves, hydro-tone dumbbells, and kickboards are instruments to be utilized in this study. The NASM recommends that a cardiorespiratory exercise be performed prior to testing and training. This included a five-minute treadmill walk.

Testing

Plank Position Assessment. The Plank Position Assessment (Appendix C1) measures neuromuscular efficiency of the core stabilization system and the movement system of the kinetic chain. This assessment is performed in a push-up like position. The subject must attempt to maintain the position for at least 20 seconds per repetition for a total
of two trials. While testing, the examiner is observing for any number of inefficiencies in the core such as feet flattening (pronate), external rotation, knees turn inward, knees bowing outward, asymmetrical weight shifting, low back arching, low back rounding, abdomen protruding, shoulder protraction, shoulder elevation, scapular winging, and/or forward head. Subjects were then scored on two variables, the number of inefficiencies seen and the level of assessment achieved. The best score of the two trials was used for the data analysis. There are six achievement levels of plank position assessment with which the subject could achieve. They were as follows: Level 0, subject was not able to get into proper plank position form with more than one to two body parts. Level 1, all but three to four body parts were able to get into proper plank position form. Level 2, able to get into the proper plank position form. Level 3, able to maintain proper plank position form for 1 - 10 seconds. Level 4, able to maintain proper plank position form for 10 - 20 seconds. Level 5, able to maintain proper plank position form for more than 20 seconds.

Overhead Squat Assessment. The Overhead Squat Assessment (Appendix C2) assesses total body neuromuscular efficiency, integrated functional strength, and functional
flexibility. This test is to be performed by the athlete, in their most comfortable position. In the assessment the athlete holds onto a broomstick just wider than shoulder width apart, elbows locked out and arms outstretched over their head. The athlete is then instructed to perform a squat while the examiner looks for any inefficiencies such as flattening of the arch of the foot, feet turning outward, asymmetry and alignment of the knee to the foot, increased curvature of the low back, asymmetrical weight shifting, shoulder protraction, elevation, abduction, winging, and forward head. The athlete must attempt to maintain the squat position for a minimum or 20 seconds per repetition for a total of two trials. Subjects were then scored on two variables, the level of assessment achieved and the number of inefficiencies seen. The best score of the two trials was used for the data analysis. There are six achievement levels of overhead squat assessment with which the subject may achieve. They are as follows: Level 0, subject is not able to get into proper overhead squat form with more than one to two body parts. Level 1, all but three to four body parts are able to get into proper overhead squat form. Level 2, able to get into the proper overhead squat form. Level 3, able to maintain proper overhead squat form for 1–10 seconds. Level 4, able to
maintain proper overhead squat form for 10 - 20 seconds. Level 5, able to maintain proper overhead squat form for more than 20 seconds.

**Overhead Medicine Ball Toss.** The Overhead Medicine Ball Toss assesses total body power. The medicine ball is not to exceed five percent of the athlete’s total body weight. The test was performed while double leg standing, single leg standing (right leg), and single leg standing (left leg) for three repetitions per stance. The test began with a medicine ball held by the athlete directly in front of them with their arms out straight. The athlete then squats down and explosively jumps up and throws the ball overhead, backwards for distance, simultaneously. The test is assessed by measuring the relative distance of the toss, measuring from the starting line to the point of first contact, as well as peak height of the ball toss. The peak height was measured by having the athlete perform the test parallel to retracted basketball bleachers which will marked according to height using a tape measure. Also to ensure the accuracy of data collection a video recorder was used to help approximate the peak height of the ball toss. Instruction of when and where to release the ball was needed to ensure optimal results. Again, the athletes best scores were used for data analysis.
Aquatic Training

Swim-Ex®. The Swim-Ex® Aquatic Therapy pool 700T-Multidepth pool was the main instrument of training used in this study. According to the manufacturers of the Swim-Ex®\textsuperscript{11}, the aquatic therapy pool is capable of providing an adjustable, smooth, broad laminar water flow, consistent throughout the entire water area. The area of the pool is 12’x6’x5’ deep, with a volume of water of 3,200 gallons. The total weight of the pool is 30,000 pounds.\textsuperscript{11}

At one end of the pool there is a paddle wheel constructed of high-density propylene, which is securely fastened with stainless steel hardware. There is also a rear mounted air-controlled safety tube, which shuts off all current to the paddle wheel by contact. At the rear of the enclosed paddle wheel pulls water from the pool and propels it downward under the false bottom floor.\textsuperscript{11}

The speed of the water flow is controlled by an AC Tech digital controller. The controller is equipped with a microprocessor and a ground fault interrupter (GFI). The pool is powered by a variable speed three-phase motor that generates over 40 water speeds, ranging from 0 to 6.5 mph (> 30,000 gal/min). There are also front air control buttons (stop, start, fast, slow) connected to air tube which connect to air sensor switches mounted at the bottom
of an electronic controller to keep electricity away from the water area.\textsuperscript{11}

The Swim-Ex\textsuperscript{®} pool contains exercise benches of varying heights and colors along with a running platform to aid in the performance of open and closed chain exercises. The pool also comes equipped with three sets of floor inserts to decrease the depth for more weight bearing activities. A stainless steel pole is provided for the easy assemble and disassembly of the floor inserts.\textsuperscript{11}

**Plyoballs\textsuperscript{™}**. Plyoballs\textsuperscript{™} are very similar to medicine balls in that they are weighted balls used for exercise training. The plyoballs\textsuperscript{™} are of five different sizes each having different weights. From the smallest ball to the largest the weight of the plyoballs\textsuperscript{™} are as follows: 2 lb’s, 4 lb’s, 7 lb’s, 11 lb’s, 17 lb’s. According to the manufacturers warning and safety precautions, each ball was used within the guidelines of proper usage.

**Aqua Gloves**. Aqua gloves are based on the principle of resistance. The gloves are made of either lycra, silicone, or neoprene. Between each finger of the glove there is webbing designed to increase the surface area of the glove. Therefore, because of the increased surface area movement of the water by the gloves is much more difficult.\textsuperscript{9,14}
Hydro-Tone Dumbbell. The hydro-tone dumbbell is a three-dimensional piece of hard plastic in the shape of a dumbbell. The dumbbell is based on the principle of resistance. Created specifically for aquatic exercise, the aquatic tool utilizes its big surface area to increase the resistance to water movement during exercise. These tools are found to be very beneficial in aerobic training, strength training, and circuit training.\textsuperscript{9,14}

Kickboard. Kickboards are narrow pieces of sleek foam ranging in size from 14" x 10" to 19" x 11.5". Kickboards take the shape of a tombstone. Kickboards were originally designed as a swimming aid but now are a critical tool in aquatic therapy and training. Based on the concept of buoyancy and resistance kickboards can be used for upper and lower body training. In the early stages of rehab and training holding the kickboard horizontally in the water gives a great deal of less resistance to water than holding it vertically, which would drastically increase the volume of water needed to be moved to perform a specific function. Special precautions were made to ensure the proper use of the equipment as well as the safety of the athlete during use.\textsuperscript{9,14}
Pilates Training

A Pilates mat was used during training sessions for subject comfort. The exercises that were used in the Pilates core training program include: standing footwork, the hundred, articulating bridge, the plank, reverse plank, rolling like a ball, and side plank. These exercises were developed in the 1920s by Joseph Pilates. Scientific validity and reliability testing has not been conducted on these exercises; however, they have been accepted by the dance and performance community as a standard means of training.

Procedures

The researcher applied for Institutional Review Board Approval (Appendix C6) at California University of Pennsylvania. Participants read and signed an Informed Consent Form (Appendix C3) as well as completed a Demographics Questionnaire (Appendix C7). The researcher or researchers chairperson answered any and all questions by the participant regarding the study promptly and efficiently.
Testing Procedure

This was a pre-test/post-test experimental design. All testing measures were recorded on a data collection sheet (Appendix C8). A cardiorespiratory warm-up is required prior to all testing and training. This was achieved by performing a comfortable five-minute treadmill walk. A two-minute rest period was allotted between each testing procedure. The plank position assessment as described in Appendix C1 was performed. Two trials were performed for a minimum of 20 seconds per repetition. Scores of the two trials were recorded on a data collection sheet to be analyzed. Instruction of proper technique was given prior to the assessment. A 30sec rest period between trials was allotted to the participant. The Overhead Squat Assessment, described in Appendix C2, was performed by the participant. Again, two trials were performed for a minimum of 20 seconds per repetition, with instruction in proper technique. Scores of the two trials were recorded on a data collection sheet to be analyzed. A 30sec rest period was allotted to the participant between each trial. Finally, the overhead medicine ball toss assessment was performed. The participant performed three double-legged trials with a 30sec rest period allowed between each trial, as well as, three single legged trials performed on the
right leg, followed by three trials to be performed on the left leg. Measuring for height and distance, the average score of the three double legged, right single leg, and left single leg trials were recorded on a data collection sheet to be analyzed.

Additionally, during the pre-testing and post-testing procedure objective information was collected from the athlete pertaining to height and weight. As well as, a Postural analysis assessment in the frontal, sagittal, and transverse plane, while standing and while walking, noting any irregularities in posture, such as upper-crossed syndrome, lower-crossed syndrome, and pronation distortion syndrome. A grading scale (Appendix C5) was constructed by the researcher pertaining to the degree of irregularity in each syndrome. The information collected during the postural analysis was used to compare possible improvements in posture due to training.

Aquatic Training

A core-training program was conducted twice a week for 30 minutes per session for six to eight weeks. The training sessions were conducted during the week and or weekend. However, they did not occur on consecutive days. Each training exercise was performed two times for 1 minute
per session. Timing was maintained by an undergraduate athletic training student to allow the researcher to oversee the rest of the session. The training sessions were conducted as follows: Five-minute cardiorespiratory warm-up (treadmill walking), Stork Standing, Stork Standing with Medicine Ball Passes, Alternating Lunges, Trunk Twists, Tuck Jumps, Shoulder Sweeps, and High Knee Running. All exercises progressed in intensity to avoid accommodation. All exercises and progressions are dually noted in Appendix C4.

The stork standing exercise was performed with the participants eyes closed at a water height of 8 - 10" below the participants chin. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

The plyoball™ toss exercise was performed with the participant’s eyes open while standing in a stork position. All of the passes were directed over the participant’s head. The athlete received as many ball passes as it took to complete the one-minute time frame against a water current intensity set at 12 red bars. Balance had to be regained before the next pass will be issued. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.
The alternating jumping lunge was performed in a water height of 8 - 10" below the participant’s chin. The participant was asked to perform as many alternating lunges as they could in one minute to the best of their ability against a distinguished water current. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

Trunk twists were performed in a water height of 8 - 10" below the participant’s chin. The athlete was instructed to perform as many 180° trunk twists necessary to fulfill the allotted one-minute exercise time. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

Tuck Jumps were performed in a water height equal to that of the participant’s shoulders. Tuck jumps include having the participant stand with their arms straight out in front of them while repeatedly jumping pulling their knees to their chest. This exercise was performed for one-minute. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

Shoulder sweeps were performed in a water height equal to that of the participant’s shoulders. The exercise involved the participant standing on one leg while
horizontally abducting and adducting their arms in a 180° sweep against a set water intensity. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

High knee running was performed in a water height equal to that of the participant’s shoulders. The exercise was performed on a stationary slanted plank within the Swim-Ex® tank against a predetermined water intensity. Progressions of the exercise ultimately depended on the participant’s ability to perform the activity without flaw.

If any participant had reached the top level of progression of any exercise, the participant remained training at that level for the duration of the study. Also, any participant missing more than two sessions, or more than one session in a week, that participant was not included in the final data analysis.

Pilates Training

Standing Footwork. This exercise is used as a warm-up. It focuses on lower body strengthening and flexibility and core stability. It strengthens the muscles of the legs and pelvis, increases hip flexibility, strengthens the core, and improves balance.
Breathing instructions for this exercise were: inhale when beginning the movement and exhale while performing the movements. A pole or wall was available for those subjects who needed balance assistance. This exercise was repeated eight times.

The subject began in the Pilates posture ("V" stance). Verbal feedback was given to each subject regarding corrections to be made. While maintaining the Pilates "V", the subject was instructed to rise up onto his toes as far as possible while still keeping the heels together. The subject then lowered back to the ground while maintaining a neutral spine during the entire movement.

Maintaining proper Pilates posture, the subject was instructed to perform a plié, bending at the hips and knees. The subjects were given verbal feedback on corrections and progress.

The final progression of this exercise combines these two movements. The subject rose onto his toes as described above. He then performed the plié, dropping his heels back onto the mat, and returned to the starting position. The subjects also performed this in reverse order.\textsuperscript{15}
Hundred. This exercise is used as a warm-up. It focuses on core strengthening and stability. The hundred increases circulation and prepares the body for other exercises. It strengthens abdominal muscles and increases spinal flexibility.

The subject were instructed to lie on his back with his arms at his side. Starting position also requires finding a neutral pelvis. The researcher assisted the subjects with this, using verbal cues and tips. The subject was instructed to curl his head and shoulders off of the floor to the point just before the neutral pelvis is lost. The arms were then moved up and down slowly, initiating movement from the shoulder joints. The subject inhaled for a count of five and exhale for a count of five, which was counted out loud by the researcher. This
exercise consisted of 10 sets of 10 seconds, totaling 100 seconds.

This exercise can be progressed by lifting the legs into a tabletop position (hips and knees bent to 90°) prior to initiating the exercise. It can also be progressed by increasing the repetitions or combining it with other abdominal exercises. Modifications can be made to alleviate pain with the exercise. The researcher provided verbal cues for corrections to posture or technique to ensure the exercise was performed correctly.\textsuperscript{15}


Articulating Bridge. The articulating bridge was used as a warm-up exercise. It focuses on core strengthening and lumbar flexibility. It increased spinal flexibility and strengthened the abdominal muscles, lower back muscles, gluteals, and hamstrings.

The subject began by lying on the mat with feet flat on the floor (knees bent). Heels were in line with the
ischial tuberosities. Arms were relaxed at the side of the body. The subject was instructed to draw his navel to his spine and begin “peeling” the vertebrae from the floor one at a time, beginning with the tailbone. The movement ended when it reached the shoulder blades. The subject then returned to the starting position by returning one vertebrae at a time to the floor.

The subject inhaled while preparing for the movement and exhaled as he lifted his torso into the bridge position. He then inhaled at the top of the position and exhaled while lowering. To progress this exercise, the subject extended one leg prior to starting to bridge. He then continued with the exercise as described above, maintaining a level pelvis with the leg extended throughout the movement. This exercise was performed eight times.\textsuperscript{15}
Plank. This exercise focuses on the upper body, core strengthening and stability, and lower body flexibility. It will strengthen the shoulders, upper back, and arms, increase stability and strength of the core, and increase flexibility of the hips.

The subject started the exercise by kneeling on the mat on all fours. Hands were aligned directly beneath shoulders and knees directly beneath hips. While keeping the shoulders wide and flat, the subject lifted into a push-up position by placing one leg at a time on the floor behind him. While maintaining body alignment, the subject extended one leg at a time. The researcher provided verbal cues for correction of body alignment or technique.

This exercise can be modified to decrease difficulty if proper body alignment cannot be maintained. It can also be modified to decrease wrist pain. The plank was progressed by bending the knee in the extended position. This exercise was performed eight times.15
Reverse Plank. This exercise focuses on core and lower body strengthening and upper body flexibility and strengthening. It strengthens the abdominals, back and hip extensors, and upper extremities. It also stretches and opens the chest and shoulders.

The subject began by sitting on the mat with his arms behind him. Weight was on the hands with fingers pointing at the heels. The subject then lifted his torso and pelvis into a plank position. The subject then rose onto one leg at a time without losing proper body alignment. The exercise was performed three times, with five alternating leg extensions on each leg.
The subject then inhaled to prepare for movement, exhaled as he lifted the torso upward, inhaled at the top position, and exhaled while lowering. When adding progression, the subject exhaled as he rose the leg and inhaled when lowering. Modifications could have been made if subjects experience wrist pain. 


Rolling Like a Ball. This exercise focuses on core strengthening and stability and spinal flexibility. It strengthens the abdominal muscles, improves balance, and increases spinal flexibility.

The subject sat near the front of the mat with the knees bent and feet flat on the mat. The subject grasped his legs behind each knee and bring his chin toward his chest. Shoulders are down and elbows are positioned up and away from the body. The subject rolls backwards to the shoulder blades. He then rolls back up and balanced on the tailbone without letting his feet touch the floor, while keeping the same body position throughout the movement.
The subject inhales while rolling back and exhales when returning. The progression for this exercise is to grasp the ankles and pull into a tighter ball. This exercise was performed eight times.\textsuperscript{15}


\textbf{Side Plank.} This exercise focuses on core and upper body strengthening and stability. It strengthens the core, arm, and upper back muscles, increases strength specifically in the quadratus lumborum, gluteus medius, and rotator cuff, and increases shoulder stability.

The subject sits on the side of his hip with the legs extended slightly in front. The subject crosses the top leg over the bottom, resting on the ball of his foot. The hand was place on the floor, aligned comfortably with the shoulder. The subject then lifts his hips off of the floor in one movement and sweeps his top arm upwards. The subject then allows the body to rest on the lower hand and foot. Ribs should be directly above the pelvis and the
shoulders and hips square with the body. The subject holds this position for a set of breaths and then lowers to the floor while maintaining body alignment. This exercise was performed five times.

The subject inhales as he prepares for the movement and exhales as he lifts into the plank position. He holds the position while inhaling and exhaling for three breathing sets. Modifications could have been made to those who were unable to support the weight of the body on one arm, as well as for those with wrist pain. This exercise can be progressed by placing one foot on top of the other, requiring more balance. It can also be combined with other movements if a subject progresses to this point.\textsuperscript{15}

Hypotheses

1. There will be a difference between the aquatic training group and Pilates training group plank position scoring levels (0 - 5), when compared to a control group.

2. There will be a difference between the aquatic training group and Pilates training group overhead squat scoring levels (0 - 5), when compared to a control group.

3. There will be a difference between the aquatic training group and Pilates training group overhead medicine ball toss measurements for height and distance of the ball tossed, when compared to a control group.

Data Analysis

The level of significance was set at $\alpha \leq 0.05$ to assess the acceptability of the stated hypotheses.

Pretest and posttest scores for each group of the dependent variables, plank position assessment, overhead
squat assessment, and overhead medicine ball toss, was used in a repeated measures test. Hypotheses 1 – 3 were analyzed by a Multivariate Analysis of Variance (MANOVA).
RESULTS

The purpose of this study was to determine if an aquatic core training and/or Pilates core training were effective techniques in increasing core strength in a training group while compared with a control group. The results are divided into three sections: demographic data, hypothesis data, and additional findings.

Demographic Data

A total number of 28 subjects began this study. The subjects were NCAA Division II college football players. Subjects were assigned to either the aquatic training group, Pilates training group or control group, and were pre and post tested. However, due to group mortality (Aquatic Group), the aquatic core training group was excluded from further involvement in the study. Therefore, the study could only be continued with the remaining two groups: Pilates and control groups.

In addition to participating in this study, all subjects were involved in a spring conditioning program initiated and instructed by the football coach and Certified Athletic Trainer. The spring program consisted
of plyometric training, speed training, and agility training.

Table 1. Demographic Data by Group

<table>
<thead>
<tr>
<th></th>
<th><strong>Pilates Training Group Means</strong></th>
<th><strong>Pilates Group Standard Deviation</strong></th>
<th><strong>Control Group Means</strong></th>
<th><strong>Control Group Standard Deviation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.55</td>
<td>1.13</td>
<td>20.28</td>
<td>1.38</td>
</tr>
<tr>
<td>Height (in)</td>
<td>75.00</td>
<td>2.17</td>
<td>72.14</td>
<td>3.18</td>
</tr>
<tr>
<td>Reported Weight (lbs)</td>
<td>286.44</td>
<td>30.61</td>
<td>219.14</td>
<td>31.44</td>
</tr>
</tbody>
</table>

Hypothesis Testing

The following hypotheses were tested for this study. All hypotheses were tested at a .05 alpha level.

A Repeated Measures MANOVA was calculated examining the effect between the Pilates core training and control group scores for the plank position assessment, overhead squat assessment, and overhead medicine ball toss. No significant group effect was found (Lambda (3,11) = .969, $P > .05$).
Hypothesis 1: There will be a difference between the Pilates training group and the control group for plank position scoring levels (0 – 5).

Conclusion: Although, no significant group effect was found, a significant test effect was identified. Improvements were seen between both group’s pre and post-test means and standard deviation statistics for the plank position assessment. The test effect may have been the result of the subjects’ post-season football training.
Hypothesis 2: There will be a difference between the Pilates training group and the control group for overhead squat scoring levels (0 - 5).

Table 4. Means and Standard Deviations for the Pilates and Control Groups Pre and Post-Test Overhead Squat Assessment.

<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilates Group Pre-Test</td>
<td>.25</td>
<td>.46</td>
</tr>
<tr>
<td>Test Overhead Squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group Pre-Test</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td>Test Overhead Squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilates Group Post-Test</td>
<td>1.50</td>
<td>1.85</td>
</tr>
<tr>
<td>Test Overhead Squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group Post-Test</td>
<td>.86</td>
<td>1.21</td>
</tr>
<tr>
<td>Test Overhead Squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: Although, no significant group effect was found, a significant test effect was identified. Improvements were seen between both group’s pre and post-test means and standard deviation statistics for the plank position assessment. Again, the test effect may have been the result of the subjects post-season football training.

Hypothesis 3: There will be a difference between the Pilates training group and the control group for overhead medicine ball toss measurements for height and distance of the ball tossed.
Table 5. Means and Standard Deviations for the Pilates and Control Groups Pre and Post-Test Overhead Medicine Ball Toss.

<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilates Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test Overhead Medicine Ball Toss</td>
<td>42.35</td>
<td>5.88</td>
</tr>
<tr>
<td>Control Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test Overhead Medicine Ball Toss</td>
<td>48.21</td>
<td>8.45</td>
</tr>
<tr>
<td>Pilates Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test Overhead Medicine Ball Toss</td>
<td>46.77</td>
<td>7.69</td>
</tr>
<tr>
<td>Control Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test Overhead Medicine Ball Toss</td>
<td>51.31</td>
<td>5.79</td>
</tr>
</tbody>
</table>

Conclusion: Although, no significant group effect was found, a significant test effect was identified. Improvements were seen between both group’s pre and post-test means and standard deviation statistics for the plank position assessment. As with hypothesis one and two, the test effect may have been the result of the subjects’ post-season football training.
Additional Findings

After testing the hypotheses, further testing and investigation was conducted to determine if there was a correlation between the groups pre and post-test overhead medicine ball toss height scores. A Pearson Product Moment Correlation was calculated to determine a relationship between the pre and post-test overhead medicine ball toss height scores. A significant correlation was found (r=.620, P=.01) between pre and post overhead medicine ball toss height scores, indicating no differences between groups.

Additional testing was also conducted to determine if there was a correlation between the groups pre and post-test overhead medicine ball toss distance scores. A Pearson Product Moment Correlation was calculated to determine a relationship in pre and post-test overhead medicine ball toss distance scores. A strong significant correlation was found (r=.831), P =.001) between pre and post overhead medicine ball toss distance scores, indicating no difference between groups.

Along with the plank position assessment and overhead squat assessment, pre and post-test scores were collected
regarding the number of inefficiencies seen in each assessment. A Repeated Measures MANOVA was used to determine if the plank position and overhead squat assessment inefficiency scores decreased between pre and post-testing. A main group effect showed that both groups did improve in the number inefficiencies seen between pre and post-testing. These results indicate improvements in core strength for both groups.

Table 6. Means and Standard Deviations for the Pilates and Control Groups Pre and Post-Test Plank Position and Overhead Squat Assessment inefficiency scores.

<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilates Group Pre-Test Plank Position Inefficiency</td>
<td>2.25</td>
<td>1.28</td>
</tr>
<tr>
<td>Control Group Pre-Test Plank Position Inefficiency</td>
<td>1.00</td>
<td>1.15</td>
</tr>
<tr>
<td>Pilates Group Post-Test Plank Position Inefficiency</td>
<td>1.38</td>
<td>.74</td>
</tr>
<tr>
<td>Control Group Post-Test Plank Position Inefficiency</td>
<td>.71</td>
<td>.49</td>
</tr>
<tr>
<td>Pilates Group Pre-Test Overhead Squat Inefficiency</td>
<td>3.50</td>
<td>1.06</td>
</tr>
<tr>
<td>Control Group Pre-Test Overhead Squat Inefficiency</td>
<td>3.57</td>
<td>.54</td>
</tr>
<tr>
<td>Pilates Group Post-Test Overhead Squat Inefficiency</td>
<td>2.13</td>
<td>1.35</td>
</tr>
<tr>
<td>Control Group Post-Test Overhead Squat Inefficiency</td>
<td>2.57</td>
<td>1.27</td>
</tr>
</tbody>
</table>
Due to aquatic group mortality, the aquatic core training subjects were excluded from group data analysis. However, one subject did fully complete the aquatic training portion of this study and was presented additionally as a case study. The aquatic training program consisted of performing specified exercises (Appendix C4) at varying levels of intensity set by the study (see the Aquatic Training portion of this study, p 19). The study lasted 4 weeks while training 2-3 times per week. This subject is a NCAA Division II college football player with no previous injuries. Demographically, he is 22 years old, 6’1” tall, and weighs 204 Lbs. The subject was highly motivated and dedicated to improving himself. He excelled very quickly through each level of aquatic training. He was pre-tested two days prior to training and post-tested two days after training. Plank Position pre-test results indicate a 50% overall gain in static core stability, a result of aquatic core stability training. Overhead medicine ball toss distance results indicate a 9.3% gain in total body power, a result of increased core strength due to training. There was no significant change in scores between pre and post-test results for his overhead medicine ball toss height. Also there was no significant change in overhead squat scores (Tables 7-9).
Table 7. Aquatic Training Subject Plank Position Pre and Post-Test Results.

<table>
<thead>
<tr>
<th>Level of Plank Position Achieved</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

A plank level of 2 indicated that prior to training the aquatic core training subject was able to get into the proper plank position, but was unable to maintain the position once testing began. A plank level of 4 indicated that the aquatic core training subject was able to maintain the proper plank position for 10 – 20 seconds.

Table 8. Aquatic Training Subject Overhead Squat Pre and Post-Test Results.

<table>
<thead>
<tr>
<th>Level of Overhead Squat Achieved</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

An overhead squat level of 1 indicated that the aquatic core training subject was unable to get into proper overhead squat position because all but one to two body parts were out of proper position.

Table 9. Aquatic Training Subject Overhead Medicine Ball Toss Pre and Post-Test Results.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>17’</td>
<td>19’</td>
</tr>
<tr>
<td>Distance</td>
<td>46’5”</td>
<td>50’1”</td>
</tr>
</tbody>
</table>

DISCUSSION
The following section is divided into three sections: discussion of results, conclusions, and recommendations.

Discussion of Results

The purpose of this study was to determine if an aquatic core training program and a Pilates core training program were effective in increasing core strength when compared to a control group. The concept of the core is believed to be the center of gravity in which all movements begin.\textsuperscript{1,2} The primary objective of core strengthening is muscular control required by specific musculature within the core to maintain functional stability.\textsuperscript{3} According to Manners and Scifers,\textsuperscript{5} core strength training allows individuals to develop an awareness of position of movement, as well as allowing muscles of the extremities to perform their functions without placing undue stress on the spine. In essence, “the core allows people to do more with less effort.”\textsuperscript{6(p61)}

It was first hypothesized that there would be a difference due to training between the Pilates training group and the control group plank position scores.
According to Clark and Russell, the plank position assessment assesses the neuromuscular efficiency of the core stabilization system and the movement system of the kinetic chain. Therefore, by performing the designated core exercises in the Pilates core training program improvements should be seen regarding static core strength and stability. The best score of the groups pre-test and post-test and the results were analyzed. Following a statistical analysis, no significant difference was found between the Pilates training group or the control group.

While it appeared that the stated hypothesis would be supported during data collection, the numeric values did not significantly increase for the plank position (static core stability). However, there was a difference in pre and post-test mean values. A mean increase of .88 level of difficulty was seen in the Pilates group, as well as a mean increase of .71 level of difficulty in the control group.

During training, the subjects orally reported feelings of getting stronger and feeling more stable, while at the post-testing, the control group reported no changes in strength and stability.

Some possible reasons that the results were not as expected are that the plank position assessment test has not been a valid and reliable measurement for core
stability at the present time. It is currently under review for validity. Another possible reason that the results were not as expected could be due to a lack of understanding and visual feedback regarding the proper position the subjects were asked to maintain. Prior to testing instruction as to proper position was shown to each subject, as well as an explanation of what was expected of them. However, some individuals did not utilize this help and only got into whatever position they felt comfortable. While others over-stressed their focus on aspects of the position they felt weak in. Another possible reason that the scores did not improve in the training group could be because there was an insufficient number of sessions of training. As well as, the intensity of each exercise could have been too low for the NCAA Division II college football athlete.

It was hypothesized that there would be a difference between the Pilates training group overhead squat scoring levels (0 - 5) (Appendix C2), when compared to a control group. A brief demonstration and instruction of the assessment was given to each subject prior to testing. Each subject was allotted two trials to perform the test. The best score of the pre-test and post-test was taken from the pilates and control groups and was analyzed. Following
a statistical analysis, no significant difference was found between the pilates training group or control group. However, a mean increase of 1.25 was found in the Pilates training group pre and post-test scores, as well as a .85 mean increase in the control groups pre/post-test scores.

One possible reason that the results were not as expected is that the overhead squat assessment test is not seen as a valid and reliable measurement for core stability as it is currently under review for validity. The National Academy of Sports Medicine states that the main objective of the overhead squat assessment is to observe for total body neuromuscular efficiency, integrated functional strength and functional flexibility. However, because a vast majority of the subjects demonstrated poor flexibility prior to training there may not have been a sufficient amount of time and training between pre-testing and post-testing to adequately produce significant results. Also, the primary focus of this study was to improve core strength, not functional flexibility, which could have led poor results found in this assessment.

Lastly, it was hypothesized that there would be a difference between the aquatic training group and Pilates training group overhead medicine ball toss measurements for height and distance of the ball tossed, when compared to a
control group. Each subject was allowed three trials to toss the medicine ball as far as they could while the instructor measured the height and distance of the ball tossed. The best pre and post-test scores for the height and distance of the ball tossed were taken and analyzed. No significant difference was found between groups. However, a mean increase of 4.42 ft was found between the training groups pre and post-test scores, as well as a 3.1 mean increase in the control groups scores.

One possible reason for this could be that there was an insufficient number of trials for the subject to perform the assessment. Many subjects could not mechanically learn how to toss the ball efficiently until their final trial. Many subjects either held the ball too long or let it go too soon giving them poor results. Due to their lack of motor learning during trials, the number of trials may have inhibited the subjects from performing to their best ability.

The researcher feels that the similarity of results between the Pilates core training group and the control group is due to the subjects post-season spring football training program. The program was set forth by their coaches, which consisted of plyometric, speed, and agility exercises. The spring football training began two weeks
prior to pre-testing and continued through post-testing. Therefore, the subjects were not only involved with a Pilates training program but also a post-season football training program as well. The researcher believes that this contributed to the correlated results, as well as, hindered other hypothesis testing results.

Although, the aquatic training group had to be excluded from the study due to group mortality, one subject did successfully complete the 10 session, 4 week program. A comparison of his testing results was done between his pre-test and post-test. In the plank position assessment the aquatic subject increased his score by 50 percent. In the Overhead medicine ball toss assessment he had an increase in distance of the ball tossed of 9.3 percent. There was no change in pre and post-test overhead squat scores. The researcher feels that the particular athlete’s core improved due to the physical properties and resistance the current provided for the athlete in the Swim-Ex®. Literature states that the buoyancy of the water dramatically decreases compression stress on weight bearing joints, bones, and muscles.\textsuperscript{9,10} The buoyant support of the water eliminates approximately 90% of a persons body weight submerged in water up to his or her neck.\textsuperscript{9} According to Clark,\textsuperscript{12} the perception of weightlessness experienced in the
water seems to decrease pain and eliminate or drastically reduce the body’s protective muscular guarding. These results could be evidence into aquatic core training being an exceptional method of core strengthening. I believe that if this group were not excluded due to mortality, the aquatic training group would have produced significant results for this study. Further investigation is needed in the area of aquatic training.

Conclusions

After a five-week Pilates core training program or five-week rest, static core strength, as measured by the plank position assessment, functional core strength, as measured by the overhead squat assessment and total body power, as measured by the overhead medicine ball toss, improved in both groups. However, subjects did improve in the quality of movement while performing the plank position assessment and the overhead squat assessment but, not significantly enough. Weight was reviewed due to a large discrepancy in group weight differences, however weight did not effect either group. Additionally, the one aquatic subject did show improvements in both the plank position assessment and the overhead medicine ball toss pre and
post-test scores. The researcher feels that the improvements and correlations found were a result of core training, as well as the concurrent post-season spring football training program.

Recommendations

While this study’s purpose was to examine the effects of training between three groups, only two groups could be analyzed due to group mortality of the aquatics training group. The following recommendations are suggested for future research in this area.

1. Allot more time for training within the study (more than 5 weeks).
2. Utilizing valid and reliable testing measures may yield better and more accurate results.
3. Do Not limit the study to test a certain group of people (football players) may ensure better commitment and dedication to the study.
4. Ensure that the subjects are not participating in an off-season strengthening program concurrently with the study.
References


APPENDIX A

Review of the Literature
Review of the Literature

Throughout the years health care professionals have studied injuries and injury trends, as well as, different methods of rehabilitation. Injuries are either labeled acute, or chronic. In the past, the primary affected area has been the focus of rehabilitation programs for injured athletes. Rehabilitation programs, traditionally, focused on absolute strength gains in isolated muscles, utilizing single plane motions. However, new trends are being developed to focus on one’s “core” as the main source of injury, rather than the specified affected area. This is due to the knowledge that all functional activities are triplanar, and require acceleration, deceleration, and dynamic stabilization. The “core” is composed of 29 muscles that attach to the lumbo-pelvic-hip complex. These muscles work synergistically to reduce force, produce force, and dynamically stabilize.

The core is the concept of the new millennium. It is the center of gravity, in which all movement begins. The notion of the core is its dependency on proper kinetic chain functional strength, and neuromuscular efficiency. Functional strength and neuromuscular
competence rely on working relationships with muscle length and tension of functional agonists and antagonists. This allows for normal force coupling within the lumbo-pelvic-hip complex.  

Some of the topics that this review covers are: The "core" anatomy, a full review of the anatomy of the core as well as their individual functions. Postural considerations for the core, what an ideal posture is and how the kinetic chain, force couples, and length-tension relationships contribute to it. This section also discusses common core and postural distortions to include the components of upper-crossed syndrome, lower, crossed syndrome, and pronation distortion syndrome and why and how they develop. This section finishes by discussing Core assessment and testing, to include different testing methods and what each test assesses. Next, aquatic training is reviewed discussing the physical properties of water such as buoyancy, specific gravity, hydrostatic pressure, viscosity, and laminar and turbulent flow. The forces of water and the advantages and disadvantages of aquatic training are also covered. Lastly, aquatic core training exercises and tools incorporated in aquatic core training is presented. However, because the concept of the core is relatively new there are few research studies
concerning aquatic core training, especially research on core training against a water current as provided by the Swim-Ex®.

The "Core" Anatomy

In order to begin to fully understand the core, we must first define what the 29 "core" muscles are. As well as, describe their normal force couple relationships; the action of two forces in opposing direction about some axis of rotation.

The first group of muscles that compose the core are the lumbar spine muscles. These include: the erector spinae group, transversospinalis muscle group, quadratus lumborum and, latissimus dorsi. The erector spinae muscle group is composed of the iliocostalis, longissimus and, spinalis. This muscle group functions to provide dynamic intersegmental stabilization and eccentric deceleration of trunk flexion and rotation during kinetic chain activities.¹,⁶

The transversospinalis group is composed of the semispinalis, multifidus, interspinalis, and intertransversali. These muscles are extremely small. They are primarily involved with intersegmental and intrasegmental stabilization, segmental eccentric
deceleration of the flexion and rotation of the trunk, as well as, conveying proprioceptive information to the central nervous system. The quadratus lumborum is mainly a frontal plane stabilizer, and works in conjunction with the gluteus medius and the tensor fascia lata. Lastly, the lattissimus dorsi, of all the lumbar spine muscles, has the greatest effect on the lumbo-pelvic-hip complex, and is the link between the upper extremity and the hip complex.¹

The next group of muscles composing the core are the abdominal muscles. The abdominal muscles are the rectus abdominus, internal oblique, external oblique, and transverse abdominus. In contraction, together the abdominals function to stabilize forces in the sagittal, frontal, and transverse planes.⁹,¹₀ Individually, the rectus abdominus functions to eccentrically decelerate trunk extension and lateral flexion, and provide dynamic stabilization during functional movements.¹ The internal obliques serve to generate ipsilateral rotation and lateral flexion, as well as, work eccentrically to decelerate extension rotation and lateral flexion.⁶ The external obliques act to concentrically create contralateral rotation and ipsilateral flexion. In addition, they eccentrically decelerate trunk extension,
rotation, and lateral flexion during functional movements. Lastly, the transverse abdominus, the most crucial of the abdominals, functions to increase intra-abdominal pressure, provide dynamic stabilization in the lumbar spine, and supply optimal neuromuscular efficiency to the entire lumbo-pelvic-hip complex.

Another group of core stabilizing muscles are the hip muscles, composed of the psoas muscle, gluteus medius, gluteus maximus, and hamstrings. Separately, the psoas muscle produces hip flexion and external rotation in the open-chain position. In the closed chain position, it acts concentrically to flex the hip, extend the lumbar spine, as well as, laterally flex and rotate the trunk. The psoas muscle eccentrically decelerates hip extension and internal rotation, as well as, trunk extension, lateral flexion, and rotation. It also works synergistically with the superficial erector spinae and creates an anterior shear force at L4 - L5. The gluteus medius functions as the primary frontal plane stabilizer during functional movements. It also decelerates femoral adduction and internal rotation during closed chain movements. The gluteus maximus is the major dynamic stabilizer of the SI joint. It functions concentrically, in the open chain, to accelerate hip
extension and external rotation. It acts eccentrically to decelerate hip flexion and femoral internal rotation. The gluteus maximus also works through the iliotibial band (IT Band) to decelerate tibial internal rotation.\textsuperscript{1,6} Finally, the hamstrings function to work concentrically to flex the knee, extend the hip, and rotate the tibia. They work eccentrically to decelerate knee extension, hip flexion, and tibial rotation.\textsuperscript{1,6}

Postural Considerations for the Core

According to Clark and Russell,\textsuperscript{7} the ideal posture consists of Ankle joints: neutral position with the leg vertical to the sole of the foot, Hip Joint: neutral position, Pelvis: the anterior superior iliac spine should be in the same vertical line as the posterior superior iliac spine, Lumbar spine: slightly convex to anterior, Scapula: Flat against upper back, Cervical spine: slightly convex to anterior, and Head: neutral position.\textsuperscript{7}

The core functions to maintain proper postural alignment and dynamic kinetics during functional activity.\textsuperscript{6,11} Structural efficiency and Functional efficiency are two major components in achieving optimal
postural alignment and dynamic kinetics. Structural efficiency is the alignment of the musculoskeletal system, which allows posture to be balanced in relation to one’s center or gravity. Functional efficiency is the ability of the neuromuscular system to perform functional tasks with the least amount of energy and creates the least amount of stress on the kinetic chain. According to Clark, proper posture and alignment allow for maximal optimal neuromuscular efficiency due to normal length-tension relationships, force couple relationships, and arthrokinematics maintenance during functional movement patterns. Which means that if one segment of the entire kinetic chain is out of place then predictable patterns of dysfunction occur throughout the entire kinetic chain.

The central nervous system (CNS) consists of the brain and spinal cord. The CNS is the integrating and command center of the nervous system, which interprets incoming sensory information and dictates responses based on previous experiences, reflexes, and current conditions. In relation to posture and control the CNS acts to optimize the selection of muscle synergies to produce movement. The CNS receives some of this information via proprioception. Proprioception is the
ability to determine the position of a joint in space. This is achieved through highly specialized neural structures called mechanoreceptors, which convert mechanical information to electrical information and relay that information to the CNS. Every structure within the Kinetic chain contains mechanoreceptors. Therefore if any structure within the kinetic chain in not functioning properly it will affect optimal neuromuscular control. Any alteration of neuromuscular control will decrease force reduction, production, and stabilization.

Common Core and Postural Distortions

As a health care professional it is only beneficial to discuss common terms and dysfunctions when studying the core. Reciprocal inhibition is a contraction of a muscle causing a reflexive relaxation in its antagonist muscle. Any alteration of this process will prevent normal force couple relationships leading to weaknesses in the core. An example of this would be a tight psoas. The tight psoas would decrease the neural drive of the gluteus maximus. Which would then decrease the force production of the gluteus maximus leading the CNS to find a compensation for the lack of force. The CNS then
activates the hamstrings and the erector spinae to make up for this decreased force production, leading to an inefficient core. This process is known as synergistic dominance. ¹⁵

Other Postural dysfunctions include upper crossed syndrome, lower crossed syndrome, and pronation distortion syndrome. Persons with rounded shoulders and a forward head posture are believed to have upper crossed syndrome.⁷ The dysfunction is mainly caused by abnormal force coupling between muscles. Upper crossed syndrome is characterized by short and tight latissimus dorsi, pectoralis major and minor, upper trapezius, levator scapulae and sternocleidomastoid in conjunction with lengthened, weak stabilizers of the scapula and deep neck flexors.⁷ Persons having an increased lumbar lordosis and an anterior pelvic tilt are said to have lower crossed syndrome. Lower crossed syndrome is characterized by having short and tight hip flexors and lumbar erectors along with lengthened and inhibited gluteus maximus and lumbo-pelvic-hip stabilizers. Finally, persons with excessive foot pronation are said to have pronation distortion syndrome.⁷ Pronation distortion syndrome is characterized by short and tight gastrocnemius, soleus, peroneals, adductors, iliotibial
band and hip flexors together with weak anterior and posterior tibialis, vastus medialis oblique, gluteus medius and hip external rotators.7

Core Assessment and testing

Before designing and implementing a core training program a proper assessment must be performed. Sufficient subjective information regarding the athlete is important to the health care professional, in designing a training program. The subjective information should include such information as to the athlete’s lifestyle, past medical history, and personal information regarding exercise habits and goals for training. Next, objective information should be collected from the athlete pertaining to height, weight, body fat percent, as well as various girth measurements. Then posture should be assessed in the frontal, sagittal, and transverse plane while standing still and while walking, checking for any irregularities such as upper-crossed syndrome, lower-crossed syndrome, and pronation distortion syndrome. This information will provide the health care professional with enough information to help design a core training program specific to the irregularity.
There are many core assessment tests to choose from. It is the job of the health care professional to learn each test and know what it is testing for. Although they are all core assessment tests that does not necessarily mean that they all test the same thing. Remember that the core is composed of 29 muscles all trying to work synergistically. A few examples of core assessment tests are the overhead squat assessment, plank position assessment, and the overhead medicine ball toss assessment. The objective of the overhead squat is to observe for total body neuromuscular efficiency, integrated functional strength and functional flexibility. The objective of the plank position assessment, is to observe neuromuscular efficiency of the core stabilization system and the movement system of the kinetic chain. Finally, the objective of the overhead medicine ball toss is to observe for total body power.

Aquatic Training

Like core training, aquatic training is also a relatively new buzzword in the health care industry. The discovery of the Hubbard tank in 1920 brought about current interests in aquatic healing techniques and
training.\textsuperscript{16} According to Tarpinian and Awbrey,\textsuperscript{17} it did not become a more reputable means of rehabilitation and training until the early 80s and 90s when professional athletes like Bo Jackson and George Brett began using it.

Aquatic rehabilitation and training has proven to have many beneficial effects for the body. Due to the buoyancy of the water it dramatically decreases compression stress on weight bearing joints, bones, and muscles.\textsuperscript{18,19} The buoyant support of the water eliminates approximately 90\% of a persons body weight submerged in water up to his or her neck.\textsuperscript{18} According to Clark,\textsuperscript{20} the perception of weightlessness experienced in the water seems to decrease pain and eliminate or drastically reduce the body’s protective muscular guarding. Aquatics has been known to increase blood circulation and promote deeper ventilation of the lungs.\textsuperscript{18} Aquatic training also has its beneficial effects on flexibility, strength and overall fitness.

\textbf{Physical Properties of Water}

Before implementing aquatic training programs, one must understand the key concepts and terms concerning aquatics. These key terms include: buoyancy, specific
gravity, hydrostatic pressure, viscosity, laminar flow, turbulent flow, and the three forces of water.

**Buoyancy.** Archimedes principle states that any object submerged or floating in water is buoyed upward by a counterforce that helps support the submerged or partially submerged object against the downward pull of gravity.\(^{19,20}\) To simplify, buoyancy assists motion toward the surface and resists motion away from the surface. It is because of buoyancy that individuals feel a sense of weightlessness when in water. The weightlessness or weight loss experience is equal to that of the water displaced when the person enters the water.\(^{19,20}\)

**Specific Gravity.** The ratio of the mass of a given volume of substance to the mass of the same volume of water.\(^{18}\) Specific gravity is determined by many factors, for example, the ratio of bone weight to muscle weight, the amount and distribution of fat, and the depth and expansion of the chest and ribs. Humans have a specific gravity less than water, on average. What this means is all objects with a specific gravity of less than one will float and objects with a specific gravity greater than one will sink. However, there is a non-uniformity of specific gravity for all body parts.\(^{20}\) So, even though humans may have a specific gravity of less than that of
Hydrostatic Pressure. The pressure exerted by any fluid on any body at rest. Hydrostatic pressure is equal on all surfaces of the body, but increases as the depth of the water increases. On the water's surface, hydrostatic pressure is equal to 14.7 pounds per square inch. However, for every added foot of depth, hydrostatic pressure increases by .433 pounds per square inch. These pressure properties cause an increase in venous blood return to the heart, decreasing heart rates associated with aquatic exercise than that of land-based exercise without losing aerobic benefits.

Viscosity. The type of resistance that occurs between the molecules of a liquid, determining its thickness and ability to flow. The higher the viscosity, the greater the resistance. Water molecules adhere to the surface of a body moving through it, therefore water acts as resistance.

Laminar and Turbulent Flow

Laminar and turbulent flow are two types of water flow. Laminar flow is defined as the smooth flow of water molecules, having the least amount of resistance because the water molecules are all in the same direction.
and speed, an example of this would be the Swim-Ex®. Turbulent flow is defined as the disruptive movement through water produced when an object encounters extreme resistance because it is not streamlined. The formula for turbulent resistance is proportional to the velocity squared.

Forces of Water

There are three forces that add resistance to water. Air has 12 times less the resistance that water does. The three forces that all contribute to this increased resistance are cohesive force, bow force, and drag force.

Cohesive Force. Cohesive force runs in a parallel direction to the water surface wherein, water molecules loosely bind together creating a surface tension, creating resistance.

Bow Force. Bow force is the force created at the front of an object during movement. When an object is in motion in the water, pressure increases at the front of the object and decreases at the rear of the object, it is these pressure differences that cause eddies. Eddies are small whirlpools caused by the movement of water from the high pressure area in front of the object to the low
pressure area in back of the object. Eddies create a backward drag force impeding flow.\textsuperscript{20,22}

**Drag Force.** Drag force is the resistance created alongside of an object causing it to move slower through the water.\textsuperscript{18,20,22} Drag force is equal to two times the speed of the moving object against water flow or turbulent water. These forces can easily be reduced by making the objects moving on the water more streamlined.\textsuperscript{18,20,22}

**Advantages and Disadvantages of Aquatic Training**

Aquatic therapy and training provides many benefits with its use. The buoyancy of the water is a great advantage. The buoyancy allows for active exercise giving the patient or athlete a sense of stability decreasing discomfort and anxiety. After injury restoring range of motion (ROM) is one of the health care professionals' top goals. Aquatic therapy provides an ideal environment to restore ROM easily by using the benefit of buoyancy in conjunction with the waters resistance and warmth. The buoyant effects of water also allows for an increased conception of control of movement.\textsuperscript{23} The water allows the client or athlete to slowly observe and control his or her movement allowing
the athlete to come across multiple errors without severe consequences. Buoyant forces also reduce apparent weight and joint compressive forces. Therefore, ambulation in water can begin much sooner than it would on land.

The force of the water are also added benefits. First, turbulence of the water provides feedback pertaining to proprioception and balance, allowing the athlete to experience multiple errors without consequences. Second, edema reduction, an important goal of the health care professional in the provision of care for clients and athletes, is achieved via hydrostatic pressure. Third, the psychological contributions of aquatic therapy including decreased tension, anxiety, and increased athlete morale due to the confidence water provides to the client during training and rehabilitation. The last benefit to aqua training is that it is an accommodating resistance medium allowing muscles to be stressed through the entire ROM available. This resistance medium provides optimal muscle education or re-education aiding in optimal muscle performance.

Although it may seem that aquatics has many advantages, there are many disadvantages. The number one disadvantage is the cost of such equipment. These
devices such as the Swim-Ex® can cost anywhere between $37,000 and $82,000. Another disadvantage to aquatic training is that strength gains largely depend on the effort exerted by the client or athlete. Stabilization will also prove to be advantageous or disadvantageous depending on the clientele. Stabilization in the water is much more difficult than it is on land, therefore, athletes who require more attention to stabilization will be more challenged.20

Finally, some contraindications for aquatic therapy and training include: open wounds or sores, contagious skin disease, excessive fear of the water and drowning, fever, urinary tract infection, allergies to the pool chemicals, cardiac problems, and uncontrolled seizures.

Aquatic Stabilization Exercises and Tools for Core strengthening

In the past when referring to the core, many people believed it only to involve the abdominal musculature. Recent literature states that the core is composed of an integrated unit of 29 muscles.1,6,7,12 Previous studies have investigated land-based core strengthening programs, but few have examined an aquatic based program and its effect on the core.
According to Panjabi et al,\textsuperscript{26} the core is the center of gravity at which all movement begins. Therefore, all exercise must effect the core. The center of gravity on land is different from that in water. To maintain the center of gravity in water the body's center of buoyancy (the chest area) and center of gravity (the core) must be in the same vertical line to each other. If the weight of a body part submerged is not equal to the liquid displaced then the center of buoyancy and center of gravity are no longer in a straight line. Therefore, the body or limb must compensate for this difference until it reaches a state of equilibrium and the center of buoyancy and center of gravity are reestablished in a vertical line again.\textsuperscript{18(p47)} Because of the instability of water there are added challenges for the core to operate optimally.

Styrofoam Weights, floatation devices, hand paddles, aqua gloves, as well as hydro-tone equipment are all types of strengthening tools used in aquatic training. Styrofoam barbells are designed to utilize the principles of resistance and buoyancy. Many of the barbell exercises were designed for upper-body training and stabilization. An example of a Styrofoam weight exercise would be to have the athlete stabilize their body in a
vertical position while holding two Styrofoam barbells directly underneath them, like a pushup. This exercise will provide upper-body strength as well as core stability as they attempt to maintain proper positioning.27

A kickboard is another tool that utilizes the principles of buoyancy and resistance. However, unlike the Styrofoam barbells, these can be used for upper and lower body strengthening.28 An example of a lower body exercise is underwater surfing, which provides proprioceptive input, leg strengthening, and core stability. An example of an upper-body exercise is trunk rotations with the kickboard while holding it in a vertical position.24,28 This exercise provides upper-body strength, as well as core stability during the maintenance of optimal body position and control while standing in the water.

Hand paddles, floatation devices, and hydro-tone equipment are all based on the principle of resistance. These tools utilize resistance by adding more surface area to the body part performing the exercise, therefore, increasing resistance. An example of an upper-body exercise would be regular free-style swimming with the aqua gloves. The aqua gloves provide more resistance to
the swimming stroke as it passes through the water. To incorporate lower-body training as well utilizing these tools one can add the hydro-tone boots, which also provide more resistance as the lower limb passes through the water.

Summary

The core, composed of 29 muscles, is the center of gravity in which all movement begins. The core is based on the concept that all functional activities are triplanar and require acceleration, deceleration, and dynamic stabilization. For optimal efficiency the core relies on normal working relationships between muscle length and tension of the functional agonists and antagonists. With this the core allows for ideal force coupling within the lumbo-pelvic-hip complex.

Any imbalances within the kinetic chain effect the core. Posture is a key consideration in the evaluation of the core. The core functions to maintain proper postural alignment and dynamic kinetics during functional activity. Optimal postural alignment and optimal dynamic kinetics rely on structural efficiency and functional efficiency which are two major components of the core.
Common core and postural distortions include reciprocal inhibition, upper crossed syndrome, lower crossed syndrome, and pronation distortion syndrome. Each of these distortions correlates to abnormal force coupling, decreasing neuromuscular efficiency, functional strength, and functional flexibility or some combination of the three.

Core training is a new concept in the reduction of such distortions and injuries. Although land based exercise has been the method of choice in the past, aquatic core training is slowly being discovered as a means to core strengthening. The physical properties of water and forces of water are the key factors in aqua training.

The physical properties include buoyancy, specific gravity, hydrostatic pressure, and viscosity. Water gives the athlete a false sense of weightlessness while submerged, which dramatically decreases compression stress on weight bearing joints, bones, and muscles. Other major contributors to aquatics are the forces of water: cohesive force, bow force, and drag force.
Water has 12 times more resistance than that of air.\textsuperscript{19} However, it is the relationship between the properties of water and the forces of water that require the core to work more efficiently to reduce, produce, and dynamically stabilize oneself while training in water.
APPENDIX B

The Problem
Statement of the Problem

Poor core strength is increasingly becoming a major factor involved with sports injuries. The primary purpose of this study was to examine the effectiveness of an aquatic core training program and a Pilates core training program in strengthening the core. The effectiveness of each core training group and a control group was evaluated by individual scoring levels (0 – 5), as well as, by the number of inefficiencies noted while administering the plank position assessment, and the overhead squat assessment. The overhead medicine ball toss test measured the effectiveness of the core training programs (aquatics and Pilates) and control by comparing measurements of height and distance of the medicine ball tossed. In addition, incidence of postural irregularities in subjects pertaining to upper-crossed syndrome, lower-crossed syndrome, and pronation distortion syndrome was evaluated to compare possible improvements in posture due to training.
Definition of Terms

The following definitions of terms are operationally defined throughout this study:

1. Core Stability – Changing the recruitment patterns of the neuromuscular system to correct asymmetries that may be due to or contribute to injury.\textsuperscript{11}

2. Functional efficiency – The ability of the neuromuscular system to perform functional tasks with the least amount of energy and creates the least amount of stress on the kinetic chain.\textsuperscript{12}

3. Hydrostatic Pressure – The pressure exerted by any fluid on any body at rest.\textsuperscript{18} Hydrostatic pressure is equal on all surfaces of the body, but increases as the depth of the water increases. On the water's surface hydrostatic pressure is equal to 14.7 pounds per square inch.

4. Neuromuscular Efficiency – The ability of the body’s neuromuscular system to synergistically reduce force, produce force, and dynamically stabilize the entire kinetic chain in all three planes of motion.\textsuperscript{7}

5. Specific Gravity – The ratio of the mass of a given volume of substance to the mass of the same volume of water.\textsuperscript{18}
6. Structural efficiency - The alignment of the musculoskeletal system, which allows posture to be balanced in relation to one’s center of gravity.\textsuperscript{12}

7. Touch-downs - Operationally defined by the researcher, is when any part of the subject's body touches any hard surface of the swim-ex® aqua tank during exercise in attempt to regain his body control.

8. Viscosity - The type of resistance that occurs between the molecules of a liquid, determining its thickness and ability to flow.\textsuperscript{18}

**Basic Assumptions**

The following are basic assumptions for this study:

1. All subjects will perform to the best of their ability.

2. The subjects will not perform a core strengthening program on their own.

3. Proper training technique will be executed in which will be ensured by the presence of instruction by the researcher.

4. The aquatic exercise performed effected the core.

5. The volume of exercise is similar between both the aquatics and Pilates Training groups
Possible Limitations of the Study

The following are limitations of the study:

1. Generalizability of results to the athletic population for Division II football players.

2. The plank position assessment, overhead squat, and the overhead medicine ball toss are currently undergoing analysis for validity and reliability.


Significance of the study

Core stabilization is having an increased effect on the athletic population today, especially in health care professional realm. Rehabilitation specialists today, are now focusing on the core as a main target for treatment and prevention.

In the past some health care professionals saw an injury or ailment and treated it directly and neglected the kinetic chain of movement. The kinetic chain is how movement and forces are transmitted through the body. An example would be a normal step in walking, forces are transmitted from the foot to the ankle, knee, hip, and finally back to the “core”. The same goes for the upper extremity forces are transmitted from the wrist to the elbow, shoulder and back to the “core”. An efficient
core allows for the maintenance of optimum length-tension relationships of functional agonists and antagonists, which makes it possible for the body to maintain optimum force-couple relationships in the lumbo-pelvic-hip complex.\textsuperscript{1} Maintaining optimum length tension relationships and force-couple relationships allows for the maintenance of optimum joint arthrokinematics in the lumbo-pelvic-hip complex during functional kinetic chain movements.\textsuperscript{1} An example is walking.

The result of this study will assist health care professionals to better understand the "core", to improve rehabilitation methods, and to assist in the prevention of injury. Furthermore, this study will give insight to varied techniques, specifically aquatic training and Pilates training, used for core strengthening.
APPENDIX C

Additional Methods
APPENDIX C1

Plank Position Assessment
Level of Plank Position Achieved

Level 0  Not able to get into proper plank position form with more than one to two body parts.

Level 1  All but three to four body parts are able to get into proper plank position form.

Level 2  Able to get into the proper plank position form.

Level 3  Able to maintain proper plank position form for 1 – 10 seconds.

Level 4  Able to maintain proper plank position form for 10 – 20 seconds.

Level 5  Able to maintain proper plank position form for more than 20 seconds.
Plank Position Inefficiencies Check List

Objective: To check off any and all inefficiencies of the core performed by the athlete during the administration of the plank position assessment per trial.

Foot and Ankle
- Feet flatten (pronate)
- Feet externally rotate (turn outward)

Knees
- Knees buckle inward
- Knees bow outward

Lumbo-Pelvic-Hip Complex
- Asymmetrical weight shifting
- Low back arches
- Low back rounds
- Abdomen protrudes

Shoulder Complex
- Shoulder Protraction
- Shoulder Elevation
- Scapular Winging

Head
- Forward head
APPENDIX C2

Overhead Squat Assessment
# Overhead Squat Inefficiencies Check List

<table>
<thead>
<tr>
<th>Total Body Profile</th>
<th>Overhead Squat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>To observe for total body neuromuscular efficiency, integrated functional strength and functional flexibility</td>
</tr>
</tbody>
</table>

## Foot and Ankle
- Feet flatten (pronate): Y / N
- Externally rotate (turn out): Y / N

## Knees
- Knees buckle inward: Y / N
- Knees bow outward: Y / N

## Lumbo-Pelvic-Hip Complex
- Asymmetrical weight shifting: Y / N
- Low back arches: Y / N
- Low back rounds: Y / N
- Abdomen protrudes: Y / N

## Shoulder Complex
- Shoulder protraction: Y / N
- Shoulder elevation: Y / N
- Shoulder abduction: Y / N
- Scapular winging: Y / N

## Head
- Forward Head: Y / N
Level of Overhead Squat Position Achieved

Level 0  Not able to get into proper overhead squat position with more than one to two body parts.

Level 1  All but three to four body parts are able to get into proper overhead squat position.

Level 2  Able to get into the proper overhead squat position.

Level 3  Able to maintain proper prone overhead squat position for 1 – 10 seconds.

Level 4  Able to maintain proper prone overhead squat position for 10 – 20 seconds.

Level 5  Able to maintain proper prone overhead squat position for more than 20 seconds.
APPENDIX C3

Informed Consent Form
Informed Consent Form

1. "Kevin Rooney, who is a certified athletic trainer and a graduate assistant, has asked for my participation in a research study at this institution. The title of the research is "The effects of aquatic core training program and a pilates core training program on core strengthening in the college athlete".”

2. "I have been informed that the purpose of this research is to determine if there are benefits to aquatic core training and pilates core training when compared to a control group.”

3. "My participation will involve me to participate in a core stabilization training program for the duration of nine weeks. The training program will require me to train twice a week for the duration of 30 minutes per session.”

4. "I understand that there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risks and/or discomforts include delayed onset muscle soreness (DOMS). However, there will be a Certified Athletic Trainer administering the training program, who is also certified in first aid, CPR, and AED (Automatic External Defibrillator) in case of any complications. Also appropriate stretching techniques and subsequent exercise sessions will be administered to offset any muscle soreness incurred due to conditioning and testing.”

5. "I understand that in case of injury I can expect to receive treatment or care in Hamer Hall’s Athletic Training Facility which will be provided by the student researcher, Kevin Rooney, ATC, or another Certified Athletic Trainer, either of which whom can administer emergency and rehabilitative care. Additional services needed for prolonged care past 3 days will be referred to the attending physician at the Downey Garofola Health Center located on campus.”

6. "I understand that there are alternative procedures available. Alternatives procedures include land based activities to strengthen the core as opposed to aquatic training.”
7. “I understand that the possible benefits of my participation in the research are increases in core stability, power, and endurance which may also decrease my susceptibility to injury. I further understand that the results of this study may also benefit society as aquatic training may provide better benefits to core stability.”

8. “I understand that the results of the research study may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Kevin Rooney, ATC, will maintain all documents in a secure location in which only the student researcher and research advisor can assess. To ensure confidentiality I will be randomly assigned an identification number to be stored in a filing cabinet under lock and key to which only the student researcher and research advisor can assess.”

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

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

Kevin Rooney, ATC
947 Cross St,
California, PA 15919,
1-781-864-0902 cell
roonkevl2@aol.com
AND/OR by:
Dr. Robert H. Kane Jr., ATC, PT, Research Advisor
250 University Ave
California, PA 15419
1-724-938-4562
kane@cup.edu

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

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

Subject’s signature_________________________Date__________________

Other Signature
(if appropriate)_________________________Date__________________

13. “I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.”

14. “I have provided the subject/participant a copy of this signed consent document if requested.”

Investigator’s signature_________________________Date__________________

Approved by the California University of Pennsylvania IRB
APPENDIX C4

Aquatic Training Exercises
Aquatic Exercises

1. Stork Standing (Single Leg Stance)

Eyes Closed, with a Swim-Ex® swimometer readout of 4.75 (See appendix C10 for the Swim-Ex® swimometer conversion chart). Positioned facing the water current, the athlete must complete an entire minute with no touch downs to advance to the next level as well as complete the entire minute without opening their eyes.

Levels of Progression 1 - 4

1) 1 minute Both arms out standing on the right leg
    1 minute Both arms out standing on the left leg

2) 1 minute Left arm out while standing on the right leg
    1 minute Right arm out while standing on the left leg

3) 1 minute Right arm out while standing on the right leg
    1 minute Left arm out while standing on the left leg

4) 1 minute Both arms by side while standing of the right leg
    1 minute Both arms by side while standing of the left leg
2. Plyoball™ Toss (Single Leg Stance), Eyes Open

Positioned facing the water current, the athlete will receive as many ball passes as it takes to complete the one-minute time frame against a swimometer readout set at 4.75. Balance must be regained before the next pass will be issued. All passes will occur overhead. The athlete must complete an entire minute with no touch downs to advance to the next level.

Levels of Progression 1 -5

2 lb. Plyoball™
1) 1 minute Both arms out standing on the right leg
   1 minute Both arms out standing on the left leg

4 lb. Plyoball™
2) 1 minute Both arms out standing on the right leg
   1 minute Both arms out standing on the left leg

7 lb. Plyoball™
3) 1 minute Both arms out standing on the right leg
   1 minute Both arms out standing on the left leg

11 lb. Plyoball™
4) 1 minute Both arms out standing on the right leg
   1 minute Both arms out standing on the left leg

15 lb. Plyoball™
5) 1 minute Both arms out standing on the right leg
   1 minute Both arms out standing on the left leg
3. Alternating Jumping Lunge

 Positioned facing the water current, the athlete will perform the exercise against water current. The athlete must complete an entire minute with no touch downs to advance to the next level.

Levels of Progression 1 - 4

1) 1 minute  Swimometer readout set at 4.75
2) 1 minute  Swimometer readout set at 5.75
3) 1 minute  Swimometer readout set at 6.75
4) 1 minute  Swimometer readout set at 7.75

4. Trunk Twists (180° Twists)

 The athlete must complete an entire minute with no touch downs or stutter stepping to advance to the next level.

Levels of Progression 1 - 4

1) 1 minute  180° trunk twists with hands together
2) 1 minute  180° trunk twists with hands together in aqua gloves
3) 1 minute  180° trunk twists with both hands holding a hydro-tone dumbbell vertically to the water
4) 1 minute 180° trunk twists while holding a kick-board vertically to the water

5. Tuck Jumps

Positioned facing the water current the athlete will perform repetitive tuck jumps. The athlete must complete an entire minute with no touch downs to advance to the next level.

Levels of Progression 1 - 4

1) 1 minute Swimometer readout set at 4.75
2) 1 minute Swimometer readout set at 5.75
3) 1 minute Swimometer readout set at 6.75
4) 1 minute Swimometer readout set at 7.75

6. Shoulder Sweeps

Positioned facing the water current, the athlete will be asked to perform repetitive shoulder horizontal abduction and adduction with a single leg stance in a water depth equal to that of the athletes shoulders. The athlete must complete an entire minute with no touch downs to advance to the next level.
Levels of Progression 1 - 4

Swimometer readout of 4.00
1) 1 minute Shoulder sweep standing on the right leg
   1 minute Shoulder sweep standing on the left leg

Swimometer readout of 4.50
2) 1 minute Shoulder sweep standing on the right leg
   1 minute Shoulder sweep standing on the left leg

Swimometer readout of 5.00
3) 1 minute Shoulder sweep standing on the right leg
   1 minute Shoulder sweep standing on the left leg

Swimometer readout of 5.50
4) 1 minute Shoulder sweep standing on the right leg
   1 minute Shoulder sweep standing on the left leg

7. High Knee Running

   Positioned facing the water current, the athlete will perform the exercise against water current. The athlete must complete an entire minute with no touch downs to advance to the next level.

Levels of Progression 1 - 4

1) 1 minute Swimometer readout set at 6.25
2) 1 minute Swimometer readout set at 7.00
3) 1 minute Swimometer readout set at 7.75
4) 1 minute Swimometer readout set at 8.50
APPENDIX C5

Postural Analysis
Additional Pre-Test / Post-Test
Objective Information

Subject ID #:__________  Group:__________
Height:__________  Weight:__________

Irregularities: Upper-Crossed Syndrome, Lower-Crossed Syndrome, Pronation Distortion Syndrome

Upper-Crossed Syndrome: Check one if applicable

Grade 1. More than one third of the athletes humeral head is positioned anterior to the acromion.\textsuperscript{29}

Grade 2. More than one third of the athletes humeral head is positioned anterior to the acromion along with lateral rotation of the olecranon process.\textsuperscript{29}

Grade 3. More than one third of the athletes humeral head is positioned anterior to the acromion along with lateral rotation of the olecranon process\textsuperscript{29} and the tip of the earlobe lies anterior to the acromion (forward head).\textsuperscript{30}
Lower-Crossed Syndrome: Check one if applicable

Grade 1. Athlete displays a mild lumbar lordosis posture along with a slight anterior pelvic tilt posture.

Grade 2. Athlete displays a moderate lumbar lordosis posture along with a moderate anterior pelvic tilt posture.

Grade 3. Athlete displays an excessive lumbar lordosis posture along with an excessive anterior pelvic tilt posture.

Pronation Distortion Disorder: Check one if applicable

Grade 1. Athlete displays excessive foot pronation while standing.

Grade 2. Athlete displays excessive foot pronation along with excessive internal rotation and valgus movement at the knee during walking.

Grade 3. Athlete displays excessive foot pronation along with excessive internal rotation at the hip and valgus movement at the knee during squatting.
APPENDIX C6

IRB Human Subjects Form
PROTOCOL for Research Involving Human Subjects

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

☐ Request for Exempt Review
☐ Request for Expedited Review
☐ Request for Full Board Review

(Reference IRB Policies and Procedures for clarification)

Project Title: The Effects of an Aquatic Core Training Program and a Pilates Core Training Program on Core Strengthening in the College Athlete

Researcher/Project Director: Kevin F. Rooney

Phone #: 781-864-0902 E-mail Address: roenkev12@nol.com

Faculty Sponsor (if you are a student): Dr. Robert H. Kane

Department: Health Science and Sports Studies

Project Dates: Jan 2005 to May 2005

Sponsoring Agent (if applicable):

Project to be Conducted at: California University of Pennsylvania (Hamer Hall)

Purpose of the Project
☐ Thesis
☐ Class Project
☐ Research
☐ Other

Required IRB Training

The training requirement can be satisfied by completing the online training session at http://coe.ncti.nih.gov. A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:
(All Proposals Must be Typed)

1. Give a brief overview of your project/proposal with research hypothesis.

Poor core strength is increasingly becoming the major factor involved with sports injuries. The primary purpose of this study is to determine whether or not aquatic or pilates core training has significant results as to increasing core strength and stability. The efficiencies of each group will be evaluated by using difficulties and abnormalities seen while administering the plank position test (measured by time and ability to maintain proper postural position), NASM’s overhead squat position test (measured by number of proper repetitions and ability to maintain proper postural position) and NASM’s overhead medicine ball toss test (measured in height and distance).

2. Give a brief description of the subjects you plan to use, and check the appropriate box(es) below.

The subjects involved in this study will include male football players from California University of Pennsylvania. Available football players will be evaluated for poor core strength and ankle stability.

- Adult Volunteers
- Minor Volunteers
- Children Under 18
- CAL University Students
- Minorities
- Disadvantaged
- Mentally Ill
- Elderly
- Mentally Retarded
- Physically Handicapped
- Prisoners
- Pregnant Women

3. Is remuneration involved in your project? ☑ Yes or ☐ No

If yes, explain below.

All Swim-Ex participants will be given pizza and soda on the final testing day.


The subjects involved in this study will include a sample of convenience of the male football players from California University of Pennsylvania. From those identified, subjects will be randomly selected to participate in the study upon their agreement. From the subjects willing to participate they will be randomly assigned to one of three research groups: Aquatic Training, Pilates Training, or a Control Group. Each subject will be provided with an informed consent form before taking part in the study. All identities will remain confidential and will not be included in the research study.
5. Does your project involve use of a consent form? ☑ Yes or ☐ No
   If yes, attach the form.

(Appendix C1)

6. What instruments or devices will be used to gather data? Provide a copy of documentation
   pertaining to the data collection, such as but not limited to:
   - Cover letter, questionnaire/survey, consent form, interview/focus group sheets.
   - Informed Consent Form, Demographics Sheet, Swim-Ex Model 700T

7. Is this project part of a grant? ☑ Yes or ☐ No
   If yes, provide the following information:
   - Title of the Grant Proposal
   - Name of the Funding Agency
   - Dates of the Project Period

8. Does your project involve the debriefing of those who participated? ☑ Yes or ☐ No
   If yes, explain the debriefing procedure.

9. The Federal Regulations require that the protocol meet certain criteria before IRB approval can be
   obtained. Describe in detail how the following requirements will be satisfied:

   A. Insure that the risks of the subject are minimized.

   Delayed onset muscle soreness (DOMS) is the only foreseeable risk involved in
   this study. Appropriate stretching techniques and subsequent exercise sessions
   will be administered to offset any muscle soreness incurred due to conditioning
   and testing.

   B. Justify the degree of risk involved (if any) in relationship to the potential of the project to the
   subject matter.

   Delayed onset muscle soreness (DOMS) is the only foreseeable risk involved in
   this study. Appropriate stretching techniques and subsequent exercise sessions
   will be administered to offset any muscle soreness incurred due to conditioning
   and testing.

   C. Insure that the selection of the subjects is equitable.

   The subjects involved in this study will include a sample of convenience of the
   male football players from California University of Pennsylvania. From those
   identified, subjects will be randomly selected to participate in the study upon their
   agreement. From the subjects willing to participate they will be randomly
   assigned to one of three research groups: Aquatic Training, Pilates Training, or a
   Control Group.
D. Guarantee that informed consent will be obtained for each prospective subject or the subject’s legally authorized representative and that consent forms will be adequately documented.

The subjects will receive an informed consent form prior to participation in this study. Each subject will be assigned an identification number ensuring the confidentiality of the subject’s identity.

E. Monitor the data collected to ensure the safety of the subject.

Subjects will receive an identification number prior to participation in this study to ensure confidentiality. Also, all data collected during this study will be collected by the researcher and will be placed under lock and key in filing cabinet only to be viewed by the researcher.

F. Protect the privacy of subjects and maintain the confidentiality of data.

Subjects will receive an identification number prior to participation in this study to ensure confidentiality. Also, all data collected during this study will be collected by the researcher and will be placed under lock and key in filing cabinet only to be viewed by the researcher.

G. Provide for extra safeguards to protect the rights and welfare of “vulnerable” subjects (e.g., children, prisoners, pregnant women, mentally disabled persons or economically or educationally disadvantaged persons).

Project Director’s Certification
Program Involving HUMAN SUBJECTS

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

If the Board grants approval of this application, I agree to:

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

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

Signature of Project Director

Signature of Department Chairperson

Student Research

Signature of Student Researcher

Signature of Faculty Member

Signature of Department Chairperson

*************

ACTION OF REVIEW BOARD

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

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

BOARD DISPOSITION:

Chairperson, Institutional Review Board

Date
APPENDIX C7

Demographics
Demographic Questionnaire

Subject #:_________________ Group #:________________

Age:__________
Height:__________ Weight:__________
Number of years in college football:__________
Position:________________________
Starter: Yes_________ No_________

Have you had an injury to any of the following body parts (indicate by circling injury):

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<th>Dislocation</th>
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<td>Foot</td>
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Are you involved in any extracurricular training program?
Yes_____ No_____ If yes, what?__________________________________________
APPENDIX C8

Testing Data Collection Sheet
Pre-Test Results Sheet

Subject ID #:______________ Date:____________

Group:______________

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<td>Trial 2</td>
<td>Trial 3</td>
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### Overhead Squat Assessment

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### Overhead Medicine Ball Toss

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APPENDIX C9

Aquatic Exercise Data Collection Sheet
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APPENDIX C10

Swim-Ex® Water Current

Conversion Chart
Swim-Ex® Water Current Conversion Chart

A swimometer meter comes standard with all models of the Swim-Ex® aqua tank. The meter is used as a visual aid to give input pertaining to the intensity of the water current. The meter is typically mounted on a wall or nearby surface for the swim-ex® trainer or trainee to view and to adjust the difficulty of their training sessions accordingly. The meter is numbered one through ten and it progresses to each new level in increments of .25 (denoted by red bars).
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<th>Miles Per Hour</th>
<th>Velocity (Ft./second)</th>
<th>Pounds Per Square Foot</th>
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APPENDIX C11

Pilates Pictures Consent Form
December 8, 2004

Ms. Romani-Ruby and Ms. Clark:

I am a graduate student at California University of Pennsylvania. I am conducting a graduate level research study. The title of the study is: The effect of a core strengthening program on lower extremity functional ability. The purpose of the study is to investigate two methods of core strengthening, an aquatic program and a Pilates program, and how they affect lower extremity functional ability. These two groups will be compared to a control group to determine the extent of change.

I plan to use the following exercises in my study: standing footwork, hundred, articulating bridge, plank, reverse plank, side plank, and rolling like a ball. I would like to use your text “Pilates Mat Work: A Manual for Fitness and Rehabilitation Professionals” to reference the descriptions of these exercises in my thesis. I would also like to use the pictures you include in your descriptions of the following exercises: standing footwork on page 115, hundred on page 36, articulating bridge on page 50, plank on page 70, reverse plank on page 72, side plank on page 74, and rolling like a ball on page 104.

As this thesis will be published online, I would like your consent to use the descriptions and pictures from your text. A statement providing consent is provided below. Thank you.

Sincerely:

Kevin F. Rooney, ATC

I hereby provide consent for Kevin F. Rooney, ATC to use the following exercise descriptions and pictures from my text “Pilates Mat Work: A Manual for Fitness and Rehabilitation Professionals”: standing footwork page 115, hundred page 36, articulating bridge page 50, plank page 70, reverse plank page 72, side plank page 74, and rolling like a ball page 104.

Signature: [Signature]
Date: 12-08-04

Signature: [Signature]
Date: 12-08-04
REFERENCES


24. Manners J, Scifers JR. Aquatic rehabilitation for core stabilization. Athletic Therapy Today. 2003; 8 (5); 68-70


Abstract

TITLE: THE EFFECTS OF AN AQUATIC CORE TRAINING PROGRAM AND A PILATES CORE TRAINING PROGRAM ON CORE STRENGTHENING IN THE COLLEGE ATHLETE

RESEARCHER: Kevin F. Rooney, ATC

ADVISOR: Dr. Robert H. Kane Jr., ATC, PT

PURPOSE: The purpose of this study was to determine if an aquatic core training or Pilates core training program was effective in increasing core strength when compared to a control group.

METHOD: Twenty-eight volunteer NCAA Division II college football athletes participated in this study. The subjects were assigned to either a Pilates core training group or a control group. All subjects were pre and post-tested using the overhead squat assessment, overhead medicine ball toss assessment, and a modified plank position assessment. The training groups went through a five-week, 10 session, aquatic or Pilates core strengthening program. After five-weeks, subjects from all groups were post-tested according to pre-testing procedures. All data was recorded and analyzed using a repeated measures MANOVA at the .05 alpha level.

FINDINGS: The five-week study did not significantly affect the core strength scores for the Pilates or control group. However, group mean scores showed an increase in scoring between pre and post-testing for the Pilates group and control group. A mean increase of .88 level of difficulty was found in the Pilates group plank position scores, as well as a 1.25 level of difficulty increase in overhead squat scores, and a 4.42ft increase in overhead medicine ball toss scores. The aquatic core training group was excluded from all data analysis due to group mortality. Additional, results were taken
from one Aquatic Training group subject who successfully completed the aquatic training program. These results showed a 50% increase in his plank position score, as well as, a 9.3% increase in his overhead medicine ball toss distance score. These results indicate improvements in static core strength (Plank Position Assessment) and total body power (Overhead Medicine Ball Toss Assessment).

CONCLUSIONS: After a five-week Pilates core training program or five-week rest, static core strength, as measured by the plank position assessment, functional core strength, as measured by the overhead squat assessment and total body power, as measured by the overhead medicine ball toss, improved in both groups. However, subjects did improve in the quality of movement while performing the plank position assessment and the overhead squat assessment but, not significantly enough. Weight was reviewed due to a large discrepancy in group weight differences, however weight did not effect either group. Additionally, the one aquatic subject did show improvements in both the plank position assessment and the overhead medicine ball toss pre and post-test scores. The researcher feels that the improvements were a result of core training, as well as the concurrent post-season spring football training program.