LOWER BODY AND CORE MEDICINE BALL TRAINING AND ITS EFFECTS ON BAT VELOCITY OF DIVISION II FASTPITCH SOFTBALL PLAYERS

By

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In partial fulfillment of the requirements for the degree,
Masters of Science in Human Performance and Physical Education,
has been approved and accepted by the following:

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Abstract

With the lack of research on women's fastpitch softball, the current study aimed to identify if a lower body and core medicine ball training program caused an increase in bat swing velocities in division II fastpitch softball players. After University IRB approval, 16 division II female fastpitch softball players (age: 20.7 ± 1.19 years; height: 165.76 ± 6.68cm; weight: 146.50 ± 24.09lbs) volunteered to participate in this study. Training compliance rate for the experimental group was 91.0% and for the 91.5% for the control. Pre and post-test values of bat swing velocity, body fat percentage, lean body mass, and a 1RM of a weighted squat were collected. Participants were randomly placed in the experimental or control training group. The experimental group performed the regular in season strength and conditioning program, as well the sport specific medicine ball training program. The control group performed the regular in season strength and conditioning program, as well as a training program consisting of additional medicine ball exercises to assure an equal volume of training was done for both groups. Both groups completed their regular in season lifting as well as the additional medicine ball exercises on the same two days for a total of eight weeks (16 total training day). Results showed significant increases ($p < 0.05$) in average bat swing velocity and the 1RM of a weighted squat, from pre-testing to post testing for both groups. The experimental group experienced greater increases in bat swing velocity and 1RM weighted squat than the control group. However, when comparing the results from the experimental group to the control training group, there were no statistical differences. The results of the current study suggest that a lower body and core medicine ball training program, with division II fastpitch softball players, produces increases in bat swing velocity and in a 1RM weighted squat.

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Chapter 1: Introduction

The roots of softball originate from an indoor version of baseball, popular in the United States in the late 1800s (Flyger, Button & Rishiraj, 2006). By the 1930s, the sport was officially recognized with the name 'softball' and was largely played as an outdoor sport. Since these times, softball has dramatically grown in popularity around the world (Lund & Heefner, 2005). Worldwide, millions of people play slow-pitch softball as a recreational sport; however at the elite international level, fastpitch softball is the dominant discipline (Flyger et al., 2006).

Fastpitch softball is a contest between two teams, at least nine players on each team, on a large diamond shaped field. A maximum of seven innings (or up to an agreed time limit) are played during which the teams alternate between batting and fielding (Flyger et al., 2006). The purpose is to score more runs while batting than the other team by the end of the seven innings or the time limit. At the collegiate level, hitters will see pitching speeds up to 70 miles per hour. Due to high velocity pitching speeds, fastpitch softball players at the collegiate level have less than 500ms (0.5s) to make the decision to swing and to complete the swing once the pitch is thrown. By increasing bat velocity, decision time could increase as well. Decision time is the amount of time the hitter has to read the pitch and decide to swing. As bat velocity improves, decision time increases, and the chance of making a correct decision increases (Lund & Heefner, 2005). This could possibly put the hitter at an advantage over the pitcher.

There is a wide variety of brands and models of fastpitch softball bats that are available for athletes to use. Alloy bats are generally constructed out of aluminum or aluminum that is mixed with other metals to make a stronger product. Composite bats are made out of a mixture of carbon fiber, graphite, fiberglass, and sometimes Kevlar. Both types are used at the collegiate level. For this study participants used an Easton 2013 Power Brigade FX2 -9 fast pitch bat, 34 inches in length and 25 ounces in weight with a 2 ¼ inch composite barrel. This model bat has been approved by the Amateur Softball Association (ASA), United States Specialty Sports Association (USSSA), National Softball Association (NSA), and the Independent Softball Association (ISA) to be used by collegiate fastpitch softball players.

Strengthening main muscle groups used during a bat swing through a medicine ball training program could increase peak and average bat swing velocity. Before attempting a core strength or medicine ball training program it is important to identify the anatomy involved in a bat swing. The main muscles responsible for the quick, ballistic, and rotational movements are the rectus abdominis, external and internal obliques, transversus abdominis, and the erector spinae (Szymanski & Fredrick, 1999). Utilization of these muscles allows the trunk to flex, extend, and rotate. Three main lower body muscles are recruited during the swing as well, starting with the gastrocnemius, biceps femoris, and then the gluteus maximus (Reyes, Dickin, Crusat, & Dolny, 2011).

Multiple studies have been done investigating the effects of torso rotational and medicine ball training programs on throwing velocity as well as on bat velocities in high school and professional baseball players and have shown increases in velocities (Newton & McEvoy, 1994; Szymanski & Fredrick, 1999; Szymanski, McIntyre, Szymanski, Bradford, Schade, Madsen, & Pascoe, 2007a; Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007b). For example, Szymanski et al. (2007a) showed that high school baseball players' bat swing velocity could be increased by performing rotational medicine ball exercises 2 days a week for 12 weeks. The research on collegiate fastpitch softball players is very limited and must be expanded upon.

Purpose of the study

The purpose of the current study was to identify if a lower body and core medicine ball training program produced an increase in the bat swing velocity of division II collegiate female fastpitch softball players. It was also necessary to identify the specific exercises that contribute to an increase in bat swing velocity. In order to confirm the increase in bat swing velocity was due to the specific medicine ball exercises, there was a training program for the control group to follow as well. This was carried out to equalize the volume of training between the groups. The control group performed additional medicine ball exercises as well, but the exercises followed by the control group were not sport specific.

Hypothesis

Hypothesis 1: The experimental group performing the lower body and core training program would show an increase, compared to pretest bat swing velocity, in maximal and average bat swing velocity when compared to the control group.

Hypothesis 2: The control group performing the control medicine ball training program would not show an increase, compared to pretest bat swing velocity, in maximal and average bat swing velocity when compared to the experimental group.

Delimitations

- Participants for this study were required to have at least one and a half years of division II collegiate softball experience.
- Participants were also required to have at least one and a half years of collegiate Olympic lifting experience.

- Participants were limited to Division II Rocky Mountain Athletic Conference (RMAC) Women's Fastpitch Softball players.
- Participants were aged from 19-23 years old.
- The bat swing velocity was measured using a BatMaxx 500 in Athletic Field House in Plachy Hall on the Adams State University campus.
- The training program lasted a duration of eight weeks and was progressively increased based on recommendations from the certified strength and conditioning coach.
- The study was limited to women's fastpitch softball and did not include men's baseball.
- Pitchers were excluded from the study due to lack of hitting experience.
- The training program, as well as pre and post-tests, was conducted at an altitude of 7,544ft.
- Each participant used an Easton 2013 Power Brigade FX2 -9 fast pitch bat, 34 inches in length and 25 ounces in weight with a 2 ¼ inch barrel.

Limitations

- The results are limited to the select group of athletes.
- Participants were advised to refrain from using any supplements that could cause muscular gains and affect the study; however there was no way for monitoring.
- There was no way to control the effort given by each individual athlete during training and testing sessions, although each subject was encouraged to use maximal effort during training and testing sessions.
- Training and testing sessions were conducted at an altitude of 7,544ft and results may differ if the study was conducted at sea level.

Assumptions

- Gains in bat swing velocity are due to the experimental training program and not to the increase in the volume of exercise.
- The control group would not see gains in their bat swing velocity compared to the experimental group.
- Participants gave their maximal effort when completing the specific exercises.
- Participants gave their full effort during pre and post-testing of peak and average bat swing velocity.
- It is assumed that the BatMaxx 500 is a valid measure of bat swing velocity, and is sensitive enough to measure changes in pre and post testing of bat velocity.

Definition of Terms

Average bat swing velocity- the average of all five swings taken by the participants (mph) for both pre and post-tests.

Bat quickness- the time it takes to move the bat head from the launch position to contact with the ball, which is measured in seconds (Lund & Heefner, 2005).

Bat velocity- the speed at which the bat head is traveling at the point of contact (Lund & Heefner, 2005).

Core/Torso- including all of the anatomy between the sternum and the knees with a focus on the abdominal region, low back and hips (Hibbs, Thompson, French, Wrigley, & Spears, 2008).

Core stability- the ability to stabilize the spine as a result of muscle activity (Hibbs et al., 2008).

Core strength- the ability of the musculature to produce force through contractile forces and intra-abdominal pressure (Hibbs et al., 2008).

Decision time- the amount of time the hitter has to read the pitch and decide if, when, and where to swing the bat (Lund & Heefner, 2005).

Peak bat swing velocity- the highest swing velocity (mph) of the five swings taken by the participant, for both pre and post-tests.

Chapter 2: Review of Literature

It is clear that the various motor skills associated with softball, such as pitching, batting and fielding, place considerable perceptual and physical demands upon players. Kinematic analyses of the bat swing suggest that elite hitters have approximately 200ms (0.2s) to decide whether to swing, and approximately the same duration to complete the swing (Lund & Heefner, 2005). Bat swing velocity significantly contributes to the characteristics of a good softball hitter. Increased bat swing velocity before bat-ball contact results in an increase in batted-ball velocity due to a larger transfer of momentum imparted onto the ball (Szymanski et al., 2007a). Additionally, an increase in swing velocity could possibly give the hitter more time to decide to swing, thereby increasing decision time.

According to the equation, force equals mass times acceleration, the greater the velocity of the bat at contact, the greater the force that can be imparted to the ball, and the farther the ball will travel once it is hit (Lund & Heefner, 2005). When the ball is struck by a bat traveling at a higher velocity, the ball will come off the bat with greater velocity which could result in further flight, have a better chance of traveling out of the infield, or possibly causing a fielder to make a mistake or a wrong play for the opposing team.

It is believed by softball and baseball coaches that hitting a ball successfully requires strong forearms and grip strength, recommending that a softball or baseball hitter should perform forearm, wrist, and hand grip exercises (Lund & Heefner, 2005). Biomechanic and electromyographic (EMG) studies that have investigated baseball hitting reflect that it is a sequence of coordinated muscle activity connected by three body segments (hips, torso, and arms) known as a kinetic link (Szymanski et al., 2007a). Researchers suggest that in order to improve swing velocity, strength training should emphasize multi-joint leg exercises, along with explosive hip and torso rotational strength exercises (Szymanski et al., 2007a), which was the main focus of the current study.

In order to enhance softball performance, players need to improve the way they use their body as a kinetic link. Explosive, rotational power can be developed by performing movement-specific resistance training exercises. Recent studies have shown that swinging a baseball or softball bat and performing medicine ball exercises that mimic a swing could increase torso strength (Szymanski & Fredrick, 1999).

Defining the 'Core/Torso' as it relates to Athletic Performance

Anatomically, what is included as 'the core musculature' varies from study to study (Hibbs et al., 2008). There are multiple definitions that have been used in research to describe the core as a whole. For example, the core has been described as a box or a double-walled cylinder with the abdominals as the front, paraspinals and gluteals as the back, the diaphragm as the roof and the pelvic floor and hip girdle as the bottom (Hibbs et al., 2008). Other researchers focusing on sports performance define the core as including all of the anatomy between the sternum and the knees with a focus on the abdominal region, low back and hips (Hibbs et al., 2008). For this current study the latter will be used to define 'the core/torso' region.

Core Stability and Core Strength

There is also some confusion among the research when trying to establish a clear definition of core stability and core strength, as everyone has their own opinions. Kibler, Press, & Sciascia (2006) defined core stability in a sporting environment as "the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer, and control of force and motion to the terminal segment in integrated athletic activities". This is compared to the traditional concept of strength in sport, which has been defined as the maximal force that can be generated at a specific velocity by a muscle or muscle group (Lehman, 2006). Core strength has been defined by Akuthota & Nadler (2004) as the muscular control required around the lumbar spine to maintain functional stability. A better understood definition to establish the difference between core stability and core strength is provided by Faries & Greenwood (2007): "core stability refers to the ability to stabilize the spine as a result of muscle activity, with core strength referring to the ability of the musculature to then produce force through contractile forces and intra-abdominal pressure" (Hibbs et al., 2008).

Improving Core Stability and Core Strength

There is limited research on the benefits of core stability and strength for elite athletes. With a lack of research to determine if core strength has an effect on athletic performance, Roetert (2001) reported that core stability and balance are critical for good performance in almost all sports and activities because of the 3-dimensional nature of sporting movement which demands that athletes must have good strength in the hip and trunk muscles. Some sports require good balance, some force production, and others body symmetry, but all require good core stability in all three planes of motion (Hibbs et al., 2008). Fastpitch softball players must be very agile and explosive on defense and offense. During a bat swing, having good balance and core stability will allow the hitter to utilize the body as a kinetic link. Stability is important to maintain posture throughout the swing. A lack of stability can lead to a loss of energy transfer. If there is weakness in the lower body and core muscles there will be wasted energy transfer and mostly likely a decline in performance.

A lack of core strength and stability could result in injury. Lower back pain is a common problem in any sport that requires significant rotatory or twisting motions (Hibbs et al., 2008). There is a large quantity of rotational and twisting motions involved in fastpitch softball during running, throwing, pitching, and hitting. A study done to measure the risk factors for injuries in the lower extremities in relation to core stability in athletes found that 41 (28 women, 13 men) out of 139 athletes (basketball and track) sustained 48 back or lower extremity injuries during the season (Leetun, Ireland, Willson, Ballantyne, & Davis, 2004). The athletes who sustained an injury generally had poor core stability; and the authors also concluded that there were greater demands on the female lumbo-pelvic musculature, which resulted in a greater injury risk to the lower back for female athletes (Leetun et al., 2004). It is suggested that hip and trunk weakness reduces the ability of females to stabilize the hip and trunk, due to the anatomical build of females (Leetun et al., 2004). Core training could play an important role in injury prevention, especially in females. Improving core strength will aid in core stability, and decreasing core strength will decrease core stability.

Physiologically, core strength and stability training is believed to result in a greater maximal power and allow a more efficient use of the muscles of the shoulders, arms, and legs (Hibbs et al., 2008). Injuries sustained during specific movements can be related to poor strength and endurance of certain muscle groups. Improving muscle strength and endurance has been said to reduce the risk of injury. However, it is difficult to determine if there are any benefits of a specific core stability or core strength exercise. There is not one single exercise that activates and challenges all of the core muscles; therefore, a combination of exercises are required to result in core stability and strength enhancements in an individual (Hibbs et al., 2008). Yet, Symanski et al. (2007b) found that high school baseball players increased torso rotational strength by performing a rotational medicine ball program that included exercises specific to a baseball swing.

Adaptations to Resistance Training

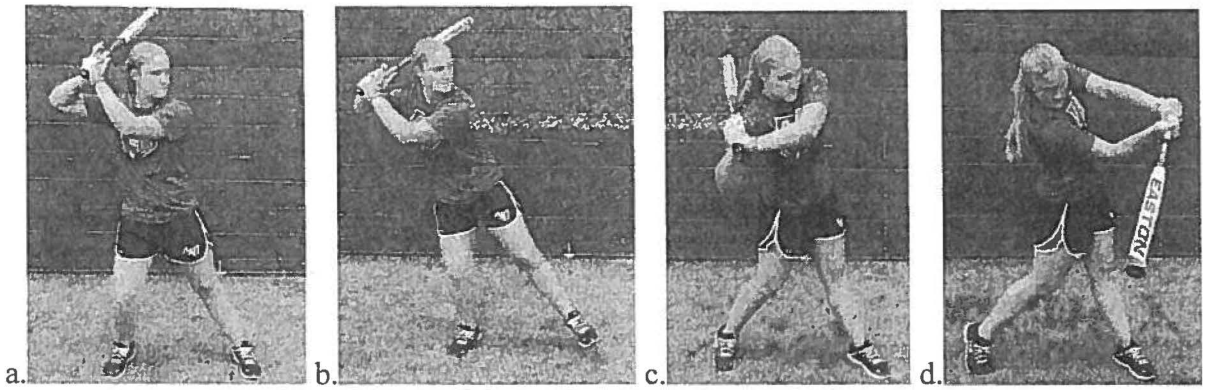
Baechle & Earle (2008) state that skeletal muscle adapts to anaerobic training primarily by increasing its size, facilitating fiber type transitions, and enhancing its biochemical and ultra-structural components (i.e., architecture, enzyme activity, and substrate concentrations).These changes result in enhanced muscular strength, power, and muscular endurance, which are critical to athletic success. Resistance training adaptions also include a change in body composition: specifically a decrease in percent body fat, and maybe more significantly, an increase in fat-free mass. As a result of these physiological adaptions, resistance training has been shown to increase tennis serve velocity, and swinging and throwing velocity (Baechle & Earle, 2008).

Breakdown of a Softball/Baseball Swing

It is important to build an understanding of what the body undergoes during a softball swing, in order to determine muscular involvement related to swing velocity. Welch, Banks, Cook, & Draovitch (1995) conducted a study to develop an understanding of baseline mechanics through quantitative biomechanical data. Thirty-nine male professional baseball players were tested at an indoor biomechanics facility. The study focused on analyzing ground reaction forces, center of mass, stride, flexion/extension, segment rotation, and bat movement. Welch et al.'s (1995) biomechanical description of hitting a baseball is:

> "The swing was initiated when the hitter shifted their weight toward their right leg (back leg). At approximately the same time the upper body rotated in a clockwise direction around the axis of the trunk, initiated by the arms and shoulders, and followed closely by the hips to form the launch phase. This then begins the coiling process (Figure 1a-b). Following the coiling, the left (front) leg was lifted and the left foot broke contact with the ground, increasing the total force applied to the right (back) foot (Figure 1b) causing a concentric muscular action in the right (back) leg. As the stride continues toward foot down, the hips begin to rotate. The shoulders continue in a clockwise direction. The arms, at the same time, continue in a clockwise rotation around the axis of the trunk, increasing the coil of the upper body against the movement of the hips and shoulders. When the heel of the left (front) foot makes contact with the ground, weight is shifted forward eccentrically (Figure 1c). When the weight is shifted forward, the left leg (front leg) extends at the knee, pushing the left hip backward, while the right leg pushes the right hip forward, creating a counterclockwise acceleration of the hips around the axis of the trunk and an eccentric muscular action (Figure 1d). The shoulders and arms will follow the lead of the hips to ball contact."

Figure 1. Fastpitch Softball Swing



Slides a-d represent the stages of a fastpitch softball swing

At ball contact, the body will use both coordination and position to generate bat speed and direction. The trunk will move through a significant range of motion in an effort to assist in bat position. After ball contact, the body will act to slow itself and the bat through eccentric muscle contractions. This study conducted by Welch et al. (1995) is only a stepping stone for the total understanding of a hitter's performance at the plate.

When comparing a fastpitch softball swing to a baseball swing the mechanics are extremely similar. Every athlete will differ in some way with the style of their swing. There are many variations in swing mechanics and how one approaches a baseball or softball swing. However, the baseline of a swing is the same for baseball and fastpitch softball (Flyger, Button, & Rishiraj, 2006).

Reyes et al. (2011) conducted an electromyographic (EMG) study that looked at the muscle activity during a baseball swing. Use of the EMG showed that during the bat swing, the order of muscle recruitment was the gastrocnemius, biceps femoris and gluteus maximus. The core musculature recruited included the external and internal obliques, transversus abdominis and the erector spinae. It has been reported that the baseball swing originates in the lower body (Reyes et al., 2011). The force generated by the lower body is then passed onto the upper body and eventually to bat ball contact (Welch et al., 1995).

Difference between Bat Velocity and Bat Quickness

Bat velocity is the speed at which the bat head is traveling at the moment of contact, however bat quickness is the time it takes to move the bat head from the launch position to contact with the ball, which is measured in seconds (Lund & Heefner, 2005). The athlete is in a launch position when the movement of the hands separate from the stride of the front foot (Figure 1b). The relationship between bat velocity and bat quickness is usually an inverse effect (Lund & Heefner, 2005). Hitters who exhibit high bat velocities tend to have slower bat quickness (high swing times). It is important to realize that high bat velocity does not necessarily mean a more productive hitter. This can be confirmed by the lower batting averages typically observed in power hitters (Lund & Heefner, 2005). Even though power hitters do normally have a lower batting average, they are still a necessity to have on a softball team. A hitter must combine bat velocity and bat quickness in order to maximize productivity (Lund & Heefner, 2005). The hitter who has a high bat velocity as well as great bat quickness, will hit for both power and a high average and will make the most impact for a team. Aspiring to increase bat velocity without negatively effecting bat quickness is the main goal of softball hitters. As stated in Lund & Heefner (2005) improving bat velocity without compromising bat quickness can be accomplished with strength and power training. To achieve this goal, appropriate musculature needs to be trained to contract more forcefully and rapidly without any changes in swing mechanics (Lund & Heefner, 2005).

Resistance Training for Female Athletes

Despite physiological differences, men and women respond to resistance exercise from their pre-training baselines in similar ways. Although the magnitudes of change in selected variables may differ somewhat, the overall trends suggest that the value of resistance exercise for women extends far beyond an increase in muscular strength, and includes favorable changes in other important measures of health and fitness, such as an increase in resistance to injuries and a reduction in the rate of bone loss (Baechle & Earle, 2008). Based on the fact that physiological characteristics of muscle fibers in men and women are the same, there is no reason why resistance training programs for women need to be different from those for men. When designing a resistance training program, the focus should be to improve the performance of the muscles needed for successful sport performance, regardless of sex (Baechle & Earle, 2008).

Medicine Ball Training

Sport specific exercises should be the main focus when establishing a medicine ball training program. The actions of hitting and throwing a softball or baseball begin with the legs and torso (Szymanski & Fredrick, 1999). According to Coleman (1998) the legs and torso form the "power zone" which generates more than 50% of the forces in hitting. If there is a weak link in the body's three link chain (legs, torso, and arms) there will be a loss of transferred forces. This loss of forces is usually due to a weak torso (Szymanski & Fredrick, 1999). Some believe that most abdominal and lower back exercises would benefit the hitter, but those exercises that involve twisting of the torso are more specific to the movement patterns of a softball swing (Lund & Heefner 2005). However, Szymanski & Fredrick (1999) stated that low-back exercises must be performed to maintain balance and strength in the low back region because lower back injuries to a softball player can severely decrease performance levels. It is suggested that torso movements that mimic the explosive, ballistic, and dynamic movements of swinging a bat should be performed. For example, the "hitters throw" is an exercise where the participant stands in his/her normal batting stance with the medicine ball held at shoulder level (where the bat would be) with both hands, then throws the ball forward with explosive rotational effort. This sport specific exercise has been used in multiple studies due to the specific movements relating to a baseball swing (Szymanski & Fredrick, 1999; Szymanski et al., 2007a; Symanski et al. 2007b).

Performing medicine ball exercises in addition to a regular strength and conditioning program has several advantages: it is inexpensive; allows a wide variety of sport specific exercises to be performed; allows athletes to strengthen the muscles of the torso in all three planes (frontal, sagittal, and transverse) of human movement; and develops sequential, explosive, rotational strength that mimic specific movement patterns (Szymanski et al., 2007a). Additionally, medicine ball tests can provide softball and baseball coaches with a means of evaluating the effectiveness of their training programs. Using electromyography, Shaffer, Jobe, Pink, and Perry (1993) explored the muscle activation patterns of various muscles during the baseball swing in professional baseball players. The authors concluded that hitters should emphasize the abdominals and muscles of the lower back due to the high muscle activity observed in these muscle groups throughout the swing (Lund & Heefner, 2005).

Newton & McEvoy (1994) investigated and compared medicine ball training to weight training and the effects on baseball throwing velocity in untrained participants. The assumption was made that medicine ball training would improve throwing velocity because the exercises are specific to a throwing motion. However, the group that used free weights improved their throwing speed to a greater degree than the group who trained with medicine balls. This could be due to the fact that the participants in the study had never been involved in regular weight training and were relatively low in strength, compared to trained athletes. Also, the medicine ball group never used a medicine ball heavier than 3-kg (6.5 pounds).

> "It is recommended that if the baseball/softball player is of low strength and has not been actively weight training, they should undergo a weight training program to increase strength. Once adequate strength has been achieved, the coach may be able to use medicine ball training after or in conjunction with weight training in a periodized model. It also appears that the weights of the medicine balls used in the training were insufficient." (Newton & McEvoy, 1994).

Based on these findings, it can be assumed that when developing a medicine ball training program, participants should be using medicine balls heavier in weight. Participants who volunteered for the current study already had at least a year and a half experience of collegiate Olympic lifting. Based on recommendations made by Newton & McEvoy (1994), the medicine balls that were used for the current study were greater than 6.5 pounds in weight.

Summary

Medicine ball exercises have been shown to increase the explosive movements in both the upper and lower body (Szymanski & Fredrick, 1999; Szymanski et al., 2007a; Symanski et al., 2007b). Sport specific medicine ball exercises are an effective method to increase bat swing velocity in sports such as hockey, golf, and baseball. The research is very limited when it comes to women's fastpitch softball. Implementing a lower body and core medicine ball training program similar to ones that have shown positive results in baseball players, could have beneficial results on increasing bat swing velocity in fastpitch softball players. Szymanksi et al.'s (2007a) results suggest that one way to enhance bat swing velocity in high school baseball players is to develop sport-specific, sequential, ballistic torso rotational strength by using medicine balls. It can be theorized that when performing a sport specific, lower body and core medicine ball training program, in addition to resistance weight training, the results could have a beneficial effect of increasing bat swing velocity in a female fastpitch softball player.

Chapter 3: Procedures

The Setting

The current study took place at Adams State University, in Alamosa, Colorado, a Division II university in the western United States, at an altitude of 7,544ft. Pre and post testing were performed indoors, in the Human Performance lab at Adams State University. All participants completed pre and post-test measurements of bat swing velocity. Anthropometric measurements including weight, height, and body composition were also taken.

In addition to attending their in-season required lifting sessions, participants were asked to volunteer for an eight-week medicine ball training program that took place two days a week. Every Tuesday and Thursday for eight weeks, the participants were asked to perform a variety of medicine ball exercises that attempted to mimic a softball swing. Training sessions were conducted in the Athletic Field House in Plachy Hall at Adams State University. Testing and training programs were all conducted during the Adams State University softball team's competitive season.

Population

A group of sixteen female fastpitch softball players from Adams State University volunteered to participate in the study (age: 20.7 ± 1.19 years; height: 165.76 ± 6.68cm; weight: 146.50 ± 24.09lbs). The Adams State University head softball coach, Dervin Taylor, gave permission for his team to participate in the eight-week training program. Sixteen participants were randomly chosen from a group of thirty-one players. Participants were then randomly divided into two equal groups. All participants completed a written informed consent that had been approved by the Adams State University Institutional Review Board (see Appendix A) before being allowed to participate in the study. The questionnaire completed before participating in the study consisted of the athlete's characteristics and past playing and exercise experience (see Appendix B). Right handed and left handed hitters were both used in the study. Pitchers were excluded from the study due to the fact that they usually do not hit during practice or a game and experienced hitters were needed. True freshmen with no collegiate softball experience or collegiate lifting experience were also excluded.

Instrumentation

Each participant was required to use the same bat for pre and post-test measurements: an Easton 2013 Power Brigade FX2 -9 fastpitch bat, 34 inches in length and 25 ounces in weight with a 2 ¼ inch barrel. Bat velocities measurements were taken using the BatMaxx 500 by having each participant perform five swings with maximal effort. All five swings were then averaged to determine the athlete's average bat velocity and was recorded in miles per hour (mph). Peak velocity, the highest of five swings, was also recorded.

Medicine balls were provided by the Adams State University weight room for the study. Medicine ball weights ranged from 12-20 pounds.

Anthropometric measurements were taken in the Human Performance lab at Adams State University. A Seca digital medical scale, Model # 220, was used to take height and weight. Lange skinfold calipers from the Human Performance lab were used to measure body composition, using a 7-site technique. Attendance logs were also be kept by the researcher to monitor training compliance.

Research Design

This study was a pretest/posttest randomized group design. Sixteen participants were randomly selected from a group of 31 players and were divided, equally, into two groups. Randomization of the groups was done by years of experience at the collegiate level (e.g. Sophomore-Senior). True freshmen and pitchers were excluded. Participants completed pre and post-test anthropometric measures including weight, height, and body composition. Bat swing velocity measurements were also taken in both the exercise and control group pre and post-intervention. Pre and post-testing of a 1-repetition maximal (1RM) squat was completed in the Plachy Hall weight room to test for any strength gains.

Group one was identified as the experimental group, performing the regular in season strength and conditioning program (Appendix C); this group also followed the sport specific medicine ball training program (see Appendix D). Group two was identified as the control group, performing the regular in season strength and conditioning program; this group also completed a training program consisting of additional medicine ball exercises to assure an equal volume of training was done for both groups (see Appendix E). The exercises for the control group were not sport specific. Both eight-week training programs were developed by the researcher and the head strength and conditioning coach at Adams State University (Appendix D & E). Each week consisted of two training days, Tuesdays and Thursdays, with one day of rest in between. Training sessions lasted for a duration no longer than 30 minutes. This approach was taken to maintain strength and power gains while decreasing the chances of overtraining and injury (Szymanski & Fredrick, 1999). Assistance and guidance from the head strength and conditioning coach was largely utilized to assure that appropriate training volumes were accomplished. The additional medicine ball exercises, in both groups, were completed prior to participants completing their regular in season strength and conditioning exercises, on the same mornings of their training sessions. Each training session began with a 5 minute warm-up consisting of dynamic exercises (Appendix F), to increase muscle blood flow and subsequent quality of exercise training (Thompson, Cobb, & Blackwell, 2007). Appendix G includes illustrative representations, with written explanations, of each exercise that was utilized in the study by the experimental group. Appendix H includes illustrative representations, with written explanations, of each exercise that was utilized in the study by the control group.

For pre and post bat swing velocity tests, the participants were required to swing from the same side throughout the entire study. For example, if the participant is a right handed hitter she was required to swing right handed for all bat swing velocity tests. Pre and posttest measures of bat swing velocity were measured in the Plachy Hall Athletic Field House at Adams State University. The participants completed the designed warm-up protocol (Appendix F) and were then instructed to take five warm-up swings by hitting regulation softballs off a tee. The height of the ball on the tee was set level with the greater tronchanter of the participant's front leg (Reyes et al., 2011). This warm-up was designed to familiarize the participant with the testing station and to reduce any pretest anxiety (Thompson, Cobb, & Blackwell, 2007). Participants were then instructed to hit an additional five balls off of the tee with maximal effort to measure bat swing velocity. Participants were not allowed to view their bat swing velocity results. Ten seconds of rest were allowed between swings. The decision to use a hitting tee was based on the desire to allow for consistent swings. The participant had to make contact with the ball during each swing allowing for the bat to pass through the laser of the BatMaxx for the velocity measurement to be recorded.

A 1RM of a weight squat was measured as well to test for any strength gains. Pre and post testing of the 1RM squat was conducted on the same day as testing of the bat swing velocity. Testing of the 1RM squat was completed after bat swing velocity was done. The testing protocol for a 1RM of a weighted squat was be taken from Beachle & Earle (2008):

> "Participants are instructed to warm up with a light resistance that easily allows 5 to 10 repetitions of a squat, a rest of 1 minute will be allowed. Participants then estimate a load that will allow them to complete three to five repetitions by adding 30 to 40 pounds, a rest of 2 minutes is then allowed. An estimate of a conservative, near-maximal load that will allow the participant to complete two or three repetitions by adding additional weight is then be completed, a 2-4 minute rest period is allowed. The participant then increases the load and attempts a 1RM. If the participant is successful, there is a 2-4 minute rest period and additional weight is then be added. If the participant fails, there is a 2-4 minute rest period, and the load is then decreased and the participant again attempts the 1RM. Increasing or decreasing the load continues until the participant can complete one repetition with proper exercise technique. Ideally, the participant's 1RM is to be measured within three to five testing sets."

Reliability and Validity

The purpose of this study was to determine if specific medicine ball exercises aimed at strengthening the lower body and core musculature would produce gains in bat swing velocity in division II fastpitch softball players. The exercises that were used in this study have been used in previous studies and have shown gains in bat swing velocity in high school baseball players as well (Szymanski et al., 2007b; Szymanski & Fredrick, 1999). Research also shows that these exercises are valid and reliable for assessing explosive power (Strockbrugger & Haennel, 2001). The training program was developed with the assistance of the head strength and conditioning coach, a certified NSCA strength and conditioning specialist, at Adams State University. Supervision by the head strength and conditioning specialist also ensured reliability.

The BatMaxx is a "vertical computerized photosensing timer" that has been used to measure the amount of time an object takes to cross two different laser beams running to two sensors (Higuchi, Nagami, Mizguchi, & Anderson, 2013). Reliability of data can be affected by aspects of swing trajectory, such as slice angle. Therefore, participants were asked to perform a level swing and to drive the ball toward the middle of the catch net. Higuchi et al. (2013) examined the test-retest reliability of the BatMaxx by completing six dry swings every day for ten days. Mean test-retest reliability of the BatMaxx was $r = 0.89$ (Higuchi et al., 2013). In addition, the mean difference between the researchers' bat swing velocity obtained from the BatMaxx and the bat swing velocity of the same swings obtained from an accelerometer attached on the barrel of the bat was less than 1% (Higuchi et al., 2013).

Skinfold measurements are an estimate of total body fatness made from measurements of subcutaneous fat at 7 different sites (chest, axilla, triceps, subscapula, suprailiac, abdomen and thigh). Paralleling the development of the advanced technologies used in body composition analysis, scientists developed equations that predict body density from a collection of skinfold measurements (Powers & Howely, 2012). Percent body fat, lean mass, and fat mass are then calculated. The researcher's validity on skin fold measurements was tested against a criterion researcher. Ten participants' seven site skin folds were measured three times, twice by the researcher and once by the criterion researcher. Reliability statistics were conducted using SPSS version 22 (2013) and Cronbach's Alpha Reliability coefficient was reported as .994 for the researcher compared to the criterion researcher. Pearson's correlation coefficient for validity was run with statistical significance set at $p < .05$. Pearson's correlation coefficient was reported at .905 which was significantly different. This indicates that the researcher is reliable for skinfold testing, but was consistently reporting lower values than the criterion researcher. The criterion researcher's mean percent body fat calculations for the ten participants was 18.4 ± 3.1% compared to the researcher's 15.6 ± 2.6%. However, the same researcher conducted all skinfold measurements for the current study, pre and post, so it can be assumed that results are both valid and reliable.

Treatment of Data/Statistical Analysis

Individual demographics were collected from all participants before testing began. Data collection of anthropometric measurements (weight, percent body fat, fat mass, and lean mass), measurement of a 1RM weighted squat, and peak and average bat swing velocity were taken twice during the course of the eight-week study, representing the dependent variables. Data collected for pre and post testing was recorded onto individual data sheets for each individual (Appendix I). Attendance logs were also kept for each participant during the eight-week training program to monitor training compliance. Make up days were arranged if participant(s) missed a training session. The days were determined to still allow one full day of rest in between training sessions. Participants were excluded from the study if less than 80 percent of the training sessions were not completed.

The medicine ball training programs represent the independent variables. Pre and post testing data collection includes records of the average bat swing velocity, as well as peak bat swing velocity and were measured in mile pėr hour (mph) and then entered into a 2013 Excel spreadsheet. This study examined changes in bat swing velocity, pre to post-test after a lower body and core medicine ball training program was completed.

Data analysis was completed by using SPSS Version 22 (2013) statistical software. Pre and post-test values of percent body fat, fat mass, lean mass, 1RM of a weighted squat, and peak and average bat swing velocity were inputted into a factorial ANOVA. The factorial ANOVA ANOVA was used to reduce the risk of committing type I error. Statistical significance will be set at $p < 0.05$.

Chapter 4: Results

A group of sixteen female fastpitch softball players from Adams State University volunteered to participate in the study (age: 20.7 ± 1.19 years; height: 165.76 ± 6.68cm; weight: 146.50 ± 24.09lbs). Prior to any data analysis participants were excluded if they had not completed at least 80 percent of the additional medicine ball training. Treatment of data was performed on both the experimental and control group. In addition to not completing at least 80 percent of the additional training, participants were excluded from data analysis if they had resigned from the team prior to completing the training program. An attendance log was maintained to monitor training compliance during the eight week program. The experimental group had an average compliance rate of 91.0% and the control group had an average compliance rate of 91.5%. After treatment of data, all participants were included in data analysis. SPSS (Version 22, 2013) was used for statistical analysis.

Data Analysis

To determine if any statistical differences existed between or within the experimental and control groups, a repeated measure analysis of variance (ANOVA) was conducted on pre and post average and peak bat swing velocity. For all data analysis, significance was set at a *p* value of .05. In addition to conducting a factorial ANOVA ANOVA, descriptive statistics (mean ± standard deviation) were collected, for both experimental and control groups, shown in Tables 4.1 and 4.2, respectively.

Table 4.1
Experimental Group Descriptive Statistics (Pre & Post Test)

Test	Mean	Average Change
Pre Test Weight (lbs)	143.20 ± 25.31	
Post Test Weight (lbs)	142.55 ± 22.77	-0.65
Pre Test % Body Fat	17.73 ± 2.37	
Post Test % Body Fat	18.21 ± 2.23	+0.48
Pre Test LBM	117.47 ± 18.81	
Post Test LBM	116.31 ± 16.59	-1.16
Pre Test Fat Mass	25.71 ± 7.32	
Post Test Fat Mass	26.23 ± 6.89	+0.52
Pre Test 1RM Squat (lbs)	190.00 ± 31.16	
Post Test 1 RM Squat (lbs)	212.50 ± 24.92	+22.5*
Pre Test Avg. Swing Velocity (mph)	48.14 ± 8.51	
Post Test Avg. Swing Velocity (mph)	55.61 ± 6.41	+7.47*
Pre Test Peak Swing Velocity (mph)	57.73 ± 9.04	
Post Test Peak Swing Velocity (mph)	60.36 ± 7.62	+2.62

+ = Increase shown
- = Decrease shown
* = Indicates significant change ($p < 0.05$)

Table 4.2
Control Group Descriptive Statistics (Pre & Post Test)

Test	Mean	Average Change
Pre Test Weight (lbs)	149.80 ± 24.03	
Post Test Weight (lbs)	147.96 ± 22.24	-1.84
Pre Test % Body Fat	18.06 ± 2.19	
Post Test % Body Fat	18.15 ± 2.12	+0.09
Pre Test LBM	122.37 ± 17.22	
Post Test LBM	120.73 ± 15.63	-1.64
Pre Test Fat Mass	27.41 ± 7.19	
Post Test Fat Mass	27.22 ± 6.81	-0.19
Pre Test 1RM Squat (lbs)	193.75 ± 22.32	
Post Test 1 RM Squat (lbs)	215.00 ± 48.99	+21.25*
Pre Test Avg. Swing Velocity (mph)	49.91 ± 10.61	
Post Test Avg. Swing Velocity (mph)	55.04 ± 15.90	+5.13*
Pre Test Peak Swing Velocity (mph)	58.78 ± 11.61	
Post Test Peak Swing Velocity (mph)	58.15 ± 16.35	-0.63

+ = Increase shown
- = Decrease shown
* = Indicates significant change ($p < 0.05$)

Results from the factorial ANOVA showed that statistically significant differences were found in both the experimental and control group when comparing pre and post testing of the average bat swing velocity, $F(1, 14) = 7.05, p = .019$. However, when the experimental group was compared to the control group there was no statistical difference in the increase in average bat swing velocity, $F(1, 14) = .243, p = .630$. Descriptive statistics showed that the experimental group had a 7.47 mph increase when comparing pre and post testing. The control group also showed an increase from pre to post testing, having a 5.13 mph increase. Even though the experimental group had a larger increase in average bat swing velocity, the difference between groups were not statistically significant. Effect size for both the experimental and control group, pre to post-testing, was considered large with a $d > 0.5$, as shown in Table 4.3. When the experimental and control group's pre and post-test average bat swing velocity were compared the effect size was considered small with a $d < 0.5$, as shown in Table 4.3. It can be hypothesized that more statistical significance could be found if a larger effect size was applied.

Peak bat swing velocity was also analyzed using the factorial ANOVA. Results showed there was no statistical difference found in either the experimental or the control group for pre to post-testing of peak bat swing velocity, $F(1, 14) = .124, p = .730$. There was also no statistical difference found when comparing the experimental group's peak bat swing velocity to the control group's peak bat swing velocity, $F(1, 14) = .334, p = .573$. Descriptive statistics showed that the experimental group's peak bat swing velocity increased by 2.62 mph from pre to post-testing. The control group's peak bat swing velocity decreased by 0.63 mph from pre to post-testing. The effect sizes for both the pre to post-testing results as a whole as well as the comparison between the experimental group and the control group were considered small with a d < 0.5, as shown in Table 4.3.

Results showed there was a significant difference found in both the experimental and control group when comparing pre and post testing of a 1RM weighted squat, $F(1, 14) = 10.26$, $p = .006$. The results for a 1RM weighted squat showed there was no statistical difference when the experimental group was compared to the control group, $F(1, 14) = .008$, $p = .928$. Descriptive statistics showed that the experimental group's 1RM weighted squat increased by 22.5 pounds. The control group also showed an increase from pre to post-testing, increasing by 21.25 pounds. Both groups showed a significant increase from pre to post-testing, however when the groups were compared there was no statistical difference. Effect size for both the experimental and control group, pre to post-testing, was considered large with a d > 0.5, as shown in Table 4.3. When the experimental and control group's results for a 1RM weighted squat were compared the effect size was considered small with a d < 0.5, as shown in Table 4.3. Correlation analyses did not indicate any significant relationships ($p > 0.05$) between improvement scores of a 1RM weighted squat and increase in average bat swing velocity.

Lean body mass as well as body fat percentage were also analyzed using the factorial ANOVA. Statistical significance was not found in either the experimental or the control group when comparing pre and post-testing of lean body mass, $F(1, 14) = 2.79$, $p = .117$. There was also no significant difference in pre and post-testing of lean body mass when the experimental group was compared to the control group, $F(1, 14) = .080$, $p = .781$. Results for body fat percentage also showed no significant difference in either the experimental or control group when comparing pre and post-testing, $F(1, 14) = 1.88$, $p = .191$. Finally, there was no statistical significance found in body fat percentage when the experimental group was compared with the control group, $F(1, 14) = .896, p = .360$.

Table 4.3
Factorial ANOVA Results

	df	*F*	*p*	*d*
ASV Pretest vs. Post-test (group as a whole)	14	7.057	.019*	.57**
ASV Experimental Group vs. Control Group	14	2.43	.630	.13
PSV Pretest vs. Post-test (group as a whole)	14	.124	.730	.09
PSV Experimental Group vs. Control Group	14	.334	.573	.15
1RM Squat Pretest vs. Post-test (group as a whole)	14	10.26	.006*	.65**
1RM Squat Experimental Group vs. Control Group	14	.008	.928	.02
LBM Pretest vs. Post-test (group as a whole)	14	2.79	.117	.41
LBM Experimental Group vs. Control Group	14	.080	.781	.07
BF% Pretest vs. Post-test (group as a whole)	14	1.88	.191	.34
BF% Experimental Group vs. Control Group	14	.896	.360	.25

ASV- Average Bat Swing Velocity
PSV- Peak Bat Swing Velocity
1RM- 1 Repetition Max
LBM- Lean Body Mass
BF%- Body Fat Percentage
* Indicates significant value (p < .05)
** Indicates large effect size (d > .5)

Another finding inferred by the results, by the researcher, is a greater consistency in average bat swing velocity by the experimental group, but not by the control group. The standard deviation for post-testing of average bat swing velocity in the experimental group decreased when compared to pre-testing, as shown in Table 4.1. The standard deviation for post-testing of average bat swing velocity in the control group increased when compared to pre-testing, as shown in Table 4.2. Standard deviation for post-testing of peak bat swing velocity in the experimental group also decreased when compared to pre-testing. The standard deviation for post-testing of peak bat swing velocity in the control group increased when compared to pre-testing.

Chapter 5: Discussion

The results, as presented in Tables 4.1-4.3, indicate that the experimental group and control group both showed significant increases in average bat swing velocity and in the 1RM of a weighted squat from pre to post-testing. However, the results also indicate that the experimental group's increases in average bat swing velocity and in the 1RM of a weighted squat was not statistically significantly different when compared to the control group's increases in average bat swing velocity and in the 1RM of a weighted squat. The experimental group, which were performing the sport specific medicine ball exercises, showed a 7.47 mph increase in average bat swing velocity, a 2.62 mph increase in peak bat swing velocity, and a 22.5 pound increase in 1RM weighted squat from pre to post test. The control group, which were performing a non-sport specific medicine ball training program, showed a 5.13 mph increase in average bat swing velocity, a 0.63 mph decrease in peak bat swing velocity, and a 21.25 pound increase in 1RM weighted squat from pre to post test.

Both groups showed statistically significant increases in the average bat swing velocity and in the 1RM weighted squat from pre to post-testing. Unlike the experimental group, the control group demonstrated a decrease in peak bat swing velocity from pre to post-testing. Despite both groups showing significant increases from pre to post-testing when the results from the experimental group were compared to the control group, in all testing interventions, there was no statistical difference. Even though a statistical difference was not shown, the experimental group had a 2.34 mph larger increase in average bat swing velocity than the control group, and the experimental group increased their peak bat swing velocity while the control group's decreased. The larger increase in average bat swing velocity and peak bat swing velocity by the experimental group can be applied to practical use by possibly improving performance and is still a significant increase. Bat swing velocity is a key component of hitting performance. Even a slight increase in batted ball speed or distance could make it possible for a ground ball that would be stopped by infielders to pass through them, or for a fly out near the fence to become a home run (Higuchi et al., 2013)

The purpose of the current study was to identify if a lower body and core medicine ball training program produced an increase in the bat swing velocity of division II collegiate female fastpitch softball players. Medicine ball exercises can incorporate the entire body and be performed ballistically and sequentially in all three planes of human movement. They can also be used to mimic any baseball/softball-specific movement. The current study lasted for a duration of eight weeks, training two days a week (16 training days). It was also an aim of the researcher to identify if sport specific exercises could contribute to an increase in bat swing velocity. Due to there being no statistical differences shown between the experimental and control group, the current sport specific medicine ball training protocol appears to have no added benefits when compared to an additional non-sport specific medicine ball training protocol. The increase in training volume for both groups could be a contributing factor to the increases in post-testing results.

The results of the study did show an increase in average bat swing velocity and in a 1RM of a weighted squat from pre to post-testing for both the experimental and control group. Both training groups improved their strength and average bat swing velocity, and the experimental group appeared to increase more. However, results did not fully support the researcher's hypotheses, which were:

Hypothesis 1: The experimental group performing the lower body and core training program will show an increase, compared to pretest bat swing velocity, in maximal (peak) and average bat swing velocity when compared to the control group.

Hypothesis 2: The control group performing the control medicine ball training program will not show an increase, compared to pretest bat swing velocity, in maximal (peak) and average bat swing velocity when compared to the experimental group.

Multiple studies have been done investigating the effects of torso rotational and medicine ball training programs on throwing velocity as well as on bat swing velocity. The sport specific exercises and training program utilized for the experimental group were selected due to success in other bat swing velocity studies (Szymanski et al., 2007a; Szymanski et al., 2007b). The exercises the previous researchers used were specific to the movements of swinging a baseball bat. Results from Szymanski et al. (2007b) indicated that a high school baseball player could statistically increase torso rotational strength by performing a resistance training program and a rotational medicine ball program, 3 days per week, for 12 weeks.

The exercises applied to the current study aimed to increase bat swing velocity in division II female fastpitch softball players. A total of seven exercises were utilized, four of which mimicked motions similar to a softball swing. Strengthening the anatomy between the sternum and the knees with a focus on the abdominal region, lower back and hips was the main focus (Hibbs et al., 2008). Two exercises focused on improving explosiveness, and utilized musculature involved in knee and hip extension, which is required in the steps of a softball swing. The final exercise utilized focused on stabilization of the abdominal region, lower back, and hips.

The rectus abdominis, external and internal obliques, transversus abdominis, and the erector spinae are the main muscles responsible for quick, ballistic, and rotational movements (Szymanski & Fredrick, 1999). Due to the need for a softball swing to be a rotational, quick and ballistic movement, these specific muscles should be trained. For a hitter, increased rotational power will produce a greater bat swing velocity. Improved velocities are desired by baseball players and coaches because it potentially equates to better performance (Szymanski et al., 2007b).

The training status of athletes affects the volume of training they will be able to tolerate. As a beginner it is appropriate for an athlete to perform only one or two sets and to add sets as he or she becomes better trained (Baechle & Earle, 2008). As athletes adapt to a consistent and well-designed program, more sets can gradually be added to match the guidelines associated with specific training goals. It has been recommended in past research that sets of 10 repetitions are ideal to increase muscular strength (Baechle & Earle, 2008). Research has also shown that three sets of six repetitions could create maximal strength gains, at least in the bench press and back squat exercises (Berger, 1963). Many studies have indicated that higher volumes are necessary to promote further gains in strength, especially for intermediate and advanced resistance-trained athletes (Baechle & Earle, 2008). Furthermore, performing three sets of 10 repetitions without going to failure enhances strength gains better than one set to failure in 8 to 12 repetitions (Baechle & Earle, 2008). Both the experimental and control training groups in the current study never exceeded three sets of 10 repetitions while performing the additional medicine ball exercises. Strength gains were shown to increase in both training groups by testing of a 1RM weighted squat.

Potential limitations and delimitations could have had effects on the current study. Participants were limited to the Adams State University softball team which is a member of the Division II Rocky Mountain Athletic Conference (RMAC). The total number of participants was 16, with 8 in each training group. Ideally, the larger the number of participants the better. Having more participants can increase the power of the study. Previous studies were able to utilize 55 participants and their results showed a more statistically significant increase in bat swing velocity (Szymanski et al., 2007a; Szymanski et al., 2007b). Finally, another potential limitation of the study was there was no way to control the effort given by each individual athlete during training and testing sessions, although each subject was encouraged to use maximal effort during training and testing sessions.

Hughes, Lyons & Mayo (2004) reported that collegiate baseball players did not show a significant increase in bat swing velocity after six weeks of training for either the control or the treatment groups. Participants completed an additional medicine ball training program while participating in a full body exercise program three times a week for six weeks. They did state that when all of the participants' data was combined, bat swing velocity did increase. It could be hypothesized that the improvements were due to the resistance training program or the volume of swings taken during baseball practice (Hughes, Lyons, & Mayo, 2004). The inferred results could also be related to the duration of the training program, being only a six week program. Participants in the current study significantly increased their bat swing velocity from pre to post-testing, however, results did not show any significant difference between the experimental and control group. It can also be hypothesized, based on past research and data from the current study, that an eight week additional medicine ball training program may not be long enough to see significant differences. Szymanski et al.'s (2007a) results suggest that one way to enhance bat swing velocity of high school baseball players is to develop a 12 week, sport-specific, sequential, ballistic torso rotational strength program by using medicine balls.

To hit a ball hard or far requires not only good eye-hand coordination and timing but also explosive hip and shoulder rotation to generate bat velocity (Hughes, Lyons & Mayo, 2004). In order to develop bat velocity softball players need to develop power. It has been suggested that power development needs to be produced sport specifically (Szymanski et al., 2007a; Szymanski et al., 2007b). Appropriate reaction time and decision time should also be developed. Due to high velocity pitching speeds, fastpitch softball players at the collegiate level have less than 500ms (0.5s) to make the decision to swing and to complete the swing once the pitch is thrown (Lund & Heefner, 2005). Improving bat swing velocity could in turn improve reaction and decision time. If a hitter has a faster bat swing velocity, they may have more time to recognize a pitch thrown at them and then, in turn, have more time to decide to complete a swing.

Recommendations

Being one of the few studies performed on female fastpitch softball players, the current findings lead to possibilities for future studies to expand on. Flyger, Button, & Rishiraj (2006) found that the combination of decreased response time associated with the softball pitch and lower batting velocities compared with baseball, indicate differences between the optimal batting techniques for each sport. Such findings provide reason to exercise caution when transferring data from baseball studies to softball studies. Due to the lack of research on female fastpitch softball players, research for the current study had to be acquired from baseball studies. Unlike sports such as baseball and golf, softball has only sporadically emerged under the research spotlight (Flyger, Button, & Rishiraj, 2006).

Future research should consider an important factor that a training protocol such as this one, should be performed in the off-season. The current study was performed in season, and presented possible restrictions in regards to the number of training days available. In season softball games are completed on weekends and the training program was completed during the middle of the week. Participants never seemed to be fully rested during the duration of the training program. Completing a study such as this one while the team is in season presents uncontrollable limitations. The researcher had no control over each participant's playing time, which could have affected the results. Conducting the study in the off-season, when there is no competitive play, could allow for a more level volume of activity. The coaching staff associated with the softball team in the current study wanted to uphold the scheduled in season lifting regimen, which focuses on full body resistance training, rather than allow the researcher to isolate specific muscle groups. Additionally, performing a similar study in the off-season can allow for more isolation of the independent and dependent variables. By performing a similar study in the off-season, a researcher would have more freedom to alter specific lifts as well as increase the total load and volume of exercise. The researcher would also have the freedom to isolate the core and lower body.

The current study was also limited to the regular in-season lifting program constructed by the strength and conditioning specialists. The researcher had no input in the program design or exercises used in the resistance training program. If performed in the off-season, it would possibly be more attainable for the researcher to have more control of the resistance training program.

Future research should consider having a larger sample size. It seems from the results that 16 participants, eight in each group, are not enough to show a significant difference between the experimental and control training programs. It can also be suggested that future research develop a training program longer than eight weeks. Past research and data from the current study seem to indicate that an eight week additional medicine ball training program may not be long enough to see significant improvements. Szymanski et al. (2007a) suggest that one way to enhance bat swing velocity of high school baseball players is to develop a 12 week, sport-specific, sequential, ballistic torso rotational strength program by using medicine balls.

Instrumentation should be taken into careful consideration as well. There is little research done on the reliability and validity of the BatMaxx 500. However, Higuchi et al. (2013) reported the mean difference between the bat swing velocities obtained from the BatMaxx and the bat swing velocity of the same swings obtained from an accelerometer attached on the barrel of the bat was less than 1%. This provides evidence that the BatMaxx 500 was sensitive enough to measure pre to post-test measures of bat swing velocity. The JUGS R1000 radar gun has also shown to be a valid and reliable instrument for measuring velocity. It has been a key instrument used during pre and post-testing and could possibly be used as an alternative instrument (Stodden, Langendorfer, & Roberton, 2009).

The population of the current study may have been a possible limitation, due to the fact that they were already trained collegiate athletes. Newton & McEvoy (1994) investigated and compared medicine ball training to weight training and the effects on baseball throwing velocity in untrained participants. The group that used free weights improved their throwing speed to a greater degree than the group who trained with medicine balls. This could be due to the fact that the participants in the study had never been involved in regular weight training and were relatively low in strength, compared to trained athletes. If trained athletes are already of adequate strength, such as the participants in the current study, results may not show a statistically significant increase after completing an eight week long medicine ball training program. Future research should look at isolating larger muscle groups of the core, hips, back, and legs to produce a more statistical significant change from pre to post testing.

Measuring explosive power of the core should also be considered for future research. The ability to generate or transfer explosive muscle power is a key element to the success of many athletic activities. Numerous tests have been designed to assess the explosive power generated by the lower body and core (Stockbrugger & Haennel, 2001). Some commonly used tests include the vertical jump, the standing long jump, and repeated bounding. All of these tests have demonstrated good reliability and have been widely used as field tests to assess overall athletic ability or the effects of specific training programs (Stockbrugger & Haennel, 2001). It is important to evaluate the effectiveness of any training program and researchers need to assess the particular components of athletic ability that are important for the sport in question.

Finally, future research could examine the relationship between reaction time and bat swing velocity on performance. The current study only looked at bat swing velocity (mph). Bat swing velocity increased in all participants of the current study, but there was no data collection on reaction time. As bat swing velocity increases, decision time increases, and the chance of making a correct decision increases (Lung & Heefner, 2005). Future research could provide evidence that as bat swing velocity increases, reaction time may increase as well. Being able to improve reaction time, in regards to a pitch thrown to the batter, may improve the hitter's chance of making a correct decision and becoming a more consistent hitter.

Chapter 6: Conclusion

The current study did not statistically support the researcher's hypothesis, that the experimental group that performed the lower body and core medicine ball training program would show more of an increase in bat swing velocity when compared to the control group. However, the experimental group still increased their bat swing velocity by 7.47 mph which is beneficial in a practical, performance sense, just not statistically significant. The control group, performing the non-sport specific exercises, increased their bat swing velocity as well by 5.13 mph. This could possibly suggest that the increase in the volume of training is not what primarily caused the increases in bat swing velocity and a 1RM weighted squat, and the increase was related to the specific exercises completed, since both groups were performing additional work. The peak bat swing velocity results also support the fact that the increase was possibly not due to the increase in volume since the experimental group increased by 2.62 mph and the control showed a decrease of 0.63 mph.

Having an increase in bat swing velocity can possibly increase performance. Increased bat swing velocity before bat-ball contact results in an increase in batted-ball velocity due to a larger transfer of momentum imparted onto the ball (Szymanski et al., 2007a). Also, increasing swing velocity could possibly give the hitter more time to decide to swing, thereby increasing decision time. The results were able to identify that an average bat swing velocity, for a division II female fastpitch softball player at altitude, is 55.61 mph. Data collection was also able to identify that the experimental group improved the 1RM weighted squat by 22.5 pounds and the control group improved by 21.25 pounds; thus, adding medicine ball exercises to an in-season resistance training program appears to be beneficial.

Virtually all softball movements (hitting, throwing, and fielding) are performed with explosive hip and torso rotation. In order to enhance softball performance, softball players and coaches need to improve the way they use their body as a kinetic link. Medicine ball training has several advantages: inexpensive; allows a wide variety of exercises; allows athletes to strengthen the muscles of the torso in all 3 planes of movement; and develops strength that mimics specific movement patterns (Szymanski et al., 2007b).

The current study also provided a foundation of research, on female fastpitch softball players, that future research could consider building and elaborating on. As the popularity of fastpitch softball continues to grow, research needs to continue to be performed to assist in the development and progress of the sport.

Based on the findings in this study, collegiate fastpitch softball players can achieve a higher average bat swing velocity, as well as a higher 1RM of a weighted squat, by performing additional medicine ball exercises. Future studies should consider multiple aspects of the current study and attempt to build and improve the research done on female fastpitch softball players. The current study aimed to address the potential volume of training issue, but more research is needed to determine whether gains and improvements are accomplished due to an increase in the volume of training or if it is in relation to the specific training program. Reliable and valid instrumentation should be utilized in future research that is sensitive enough to measure pre to post-test measurements. The current study aimed to not only identify the effects of a lower body and core medicine ball training program on bat swing velocity of division II female fastpitch softball players, but also to set a foundation of research for future researchers to build upon.

Practical Applications

Based on the findings from past research and from the current study, the use of medicine ball training to improve average bat swing velocity is beneficial. It is important to evaluate the effectiveness of any training program, whether it be the specific exercises used or the volume of training. Results from the current study show that the experimental group had a significant increase in average bat swing velocity and in a 1RM weighted squat. Participant's strength and bat swing velocity increased after performing an eight week sport specific medicine ball training program. Results also show that the control group had a significant increase in average bat swing and in a 1RM weighted squat. The control group completed an eight week non-sport specific medicine ball training program, and improvements could be due to the overall increase in training volume. However, due to the fact that the experimental group showed larger increases in average bat swing velocity, peak swing velocity, and in a 1RM weighted squat, results may suggest that improvements were due to the experimental training program which included the sport specific medicine ball exercises.

There were no statistical differences when comparing the sport specific medicine ball exercises to the non-sport specific exercises but there were significant increases in the key dependent variables. The experimental group increased their average bat swing velocity by 7.47 mph, peak swing velocity by 2.62 mph, and their 1RM weighted squat by 22.5 pounds which are significant increases in a practical sense and could be an important factor in improving athletic performance. To hit a ball hard or far requires not only good eye-hand coordination and timing but also explosive hip rotation to generate bat velocity (Szymanski et al., 2007a). In order to develop bat swing velocity, softball and baseball players need to develop torso rotational strength and power. The current study suggests that one way to enhance bat swing velocity of division II collegiate fastpitch softball players is to develop a lower body and core training program by using medicine balls.

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Appendix A: Participant Consent Form

Adams State University

Request to obtain approval for the use of human participants – expedited review

Date: November 30th, 2014

To: **Adams State University**

Request to obtain approval for the use of human participants – expedited review

Date: November 30th, 2014

To: Rob Demski, ASU Institutional Review Board

Name: Danniell Consonero
Email: consonerodj@grizzlies.adams.edu
Mailing Address: 522 Bell Ct. Apt. #1, Alamosa, CO 81101
Phone: 719-320-0038

Responsible Faculty Member

Chair of Thesis Committee: Tracey Robinson, Ph.D.
Email: tlrobins@adams.edu
Phone: 719-587-7663

Subject: Lower Body and Core Medicine Ball Training and Its Effects on Bat Velocity of Division II Fastpitch Softball Players

Others in Contact with Human Participants:

Research Assistants: Possible undergraduate students.

The title of the research: Lower Body and Core Medicine Ball Training and Its Effects on Bat Velocity of Division II Fastpitch Softball Players

Objectives of the research: Worldwide, millions of people play fastpitch softball. There are many different levels; little league, club, collegiate and professional. Multiple studies have been done investigating the effects of torso rotational and medicine ball training programs on bat swing velocities in high school and professional baseball players and were able to show increases in velocities. The research on collegiate fastpitch softball players is very limited and must be expanded on. The purpose of this study is to identify if a lower body and core medicine ball training program produces an increase in the bat swing velocity of division II collegiate fastpitch softball players. It is necessary to identify the specific exercises that contribute to an increase in bat swing velocity.

Benefits

The benefits of this study include, but are not limited to: increased bat swing velocity and an increase in lower body and core strength and power production. Identifying specific exercises that cause an increase in lower body and core strength to produce increases in bat swing velocity will also be beneficial. Many exercises have already been proven to produce an increase in bat swing velocity in males. It is crucial to determine exercises and improve knowledge that will potentially improve performance for the female, fastpitch softball population.

Risks and Discomforts

There are possible risks associated with the study that include the potential for injury to the lower back, shoulders and knees, that are associated with any lifting program. To minimize the potential of injury, the exercises will be instructed and supervised by the primary researcher and Matt Gersick (Head Strength and Conditioning Coach). Every professional effort will be made to minimize any risks involved in this study. Minimal discomfort and/ or bruising can occur during pre and post testing skin fold measurements to determine body composition (% body fat). Participants may also experience sore muscles due to the training programs. The risks of a participating in a resistance training program are less than that of playing the actual sport.

Methods of procedure:

Twenty participants will be randomly selected from a group of 39 fastpitch Division II softball players and will be divided, equally, into two groups. Group one will be identified as the experimental group, performing the regular in season strength and conditioning program; this group will also follow the medicine ball training program. Group two will be identified as the control group, performing the regular in season strength and conditioning program; this group will also have a training program to follow consisting of similar but different medicine ball exercises (non-sport specific) to assure an equal volume of training for both groups. Both eight-week training programs have been developed by the researcher and the head strength and conditioning coach. Each week will consist of two training days, Tuesdays and Thursdays, with one day of rest in between. Each training session will last a maximum of 30 minutes. Each training session will begin with 5 minutes of dynamic warm-up, to increase quality of exercise and muscle blood flow. No deception will be involved in the study.

<u>Specific pre/post laboratory tests:</u>

All participants will be asked to sign a form of consent to participate in this study. After consent has been given, participants will be asked to complete a short demographic and history survey. Participants will complete pre and post-test anthropometric measures including weight, height, and body composition (skinfold measurements via skinfold calipers).

Pre and posttests of bat swing velocity will be measured in the Plachy Hall Athletic Field House at Adams State University. Participants will be allowed to warm up with the designated bat until they feel comfortable. The participants will then be instructed to take five warm-up swings by hitting regulation softballs off a tee. The height of the ball on the tee will be set level with the greater tronchanter of the participant's front leg. This warm-up is designed to familiarize the participant with the testing station and to reduce any pretest anxiety. Participants will then be instructed to hit an additional five balls off of the tee to measure bat swing velocity. Participants will not be allowed to view their bat swing velocity results. Ten seconds of rest will be allowed between swings. The decision to use a hitting tee is based on the desire to allow for consistent swings. The participant must make contact with the ball during each swing allowing for the bat to pass through the laser of the BatMaxx. The BatMaxx500 is a "vertical computerized photosensing timer" that will be used to measure the amount of time an object takes to cross two different laser beams running to two sensors.

Pre and post-testing protocol for a 1RM of a squat will be taken from Baechle & Earle (2008): Participants will be instructed to warm-up with a light resistance that easily allows 5 to 10 repetitions of a squat, a rest of 1 minute will be allowed. Participants will then estimate a load that will allow to complete three to five repetitions by adding 30 to 40 pounds, a rest of 2 minutes will be allowed. An estimate of a conservative, near-maximal load that will allow the participant to complete two or three repetitions by adding additional weight will then be completed, a 2-4 minute rest period will be allowed. The participant will then increase the load and attempt a 1RM. If the participant is successful, there will be a 2-4 minute rest period and additional weight will be added. If the participant fails, there will be a 2-4 minute rest period, and then the load will be decreased and the participant will again attempt the 1RM. Increasing or decreasing the load will continue until the participant can complete one repetition with proper exercise technique. Ideally, the participant's 1RM will be measured within three to five testing sets. To reduce the risk for injury the pre and post-testing sessions will be monitored by a certified strength and conditioning specialist.

Research Design: This is independent research for a Masters thesis. Data will be analyzed using SPSS statistical analysis software. The independent variables in this study will be the treatment groups (experimental and control medicine ball training programs), and time of measurement (pre and post training program); the dependent variables will be the peak and average bat swing velocity as well as anthropometric measurements.

The Setting: The study will take place at Adams State University, Alamosa Colorado. All participants will complete pre and post-test measures of bat swing velocity in the Plachy Hall Athletic Field House. Anthropometric measures including weight, height, and body composition will be taken in the human performance and biomechanics lab on the Adams State University campus. Training sessions will be conducted in the Athletic Field House in the mornings, prior to the regular scheduled strength and conditioning training.

Participants: A group of twenty female fastpitch softball players from Adams State University will volunteer to participate in the study. Adams State University head softball coach Dervin Taylor has given permission for his team to participate in the eight week training program. The participant's ages will range from 19-23 years old. Right handed and left handed hitters will both be used. Pitchers will be excluded from the study due to the fact that they usually do not hit during practice or a game and experienced hitters are needed. True freshmen with no collegiate softball experience or collegiate lifting experience will also be excluded.

Protection Measures

Participation is voluntary and will be held confidential. Participants may choose not to answer any question they do not want to answer and/ or may withdraw from participation at any time without penalty. Names will not be used in the study, participants will be assigned a number and group data will be reported. Data will be locked under a password protected computer for five years in which the researcher only has the password. Adams State University reserves the right to use the results of this study for future research and/or presentation of results. In such cases, participants will be asked to sign a release form freeing all collected information prior to its use by the institution or researcher. If research is used in a public forum, data will be reported as a group without individual or school identification.

Consent: Participants will be asked to read over and sign the consent form before any testing begins. The informed consent is attached separately.

Changes: If any changes are made to the research I will contact the IRB immediately and fill out the needed paperwork.

Tracey L Robinson

Signature
Thesis Committee Chair

12-18-2014

Date

Signature

Date

Robert Demski

Signature IRB Chair

1-9-15

Date

Lower Body and Core Medicine Ball Training and Its Effects on Bat Velocity of Division II Fastpitch Softball Players
Danniell Consonero
Adams State University Human Performance and Physical Education

The purpose of this study is to identify if a lower body and core medicine ball training program produces an increase in the bat swing velocity of division II collegiate fastpitch softball players. The secondary purpose of this study is to identify the specific exercises that contribute to an increase in bat swing velocity. You have been identified by the researcher as a potential volunteer for this study because you met the criteria of being a Division II, collegiate fastpitch softball player at Adams State University.

PROCEDURES

This study will utilize 20 participants, who will be randomly assigned to one of two groups: control (regular in-season lifting with additional medicine ball exercise) and experimental (regular in-season lifting and sport specific medicine ball training program). Each training session will last a maximum of 30 minutes. Randomization of the two groups will be performed equally, based on collegiate softball experience, age, and position.

Specific Laboratory Tests Include:

All tests listed below will be performed both before the training program, and after the conclusion of the training program.

1. You will be asked to fill out a short survey asking about your demographics (age, weight, height, position, and collegiate softball experience) before testing, and after the consent for has been completed. All pre and post-testing will be performed in the Human Performance lab at Adams State University.
2. A seven-site skinfold measurement will be taken using skinfold calipers to determine your body composition.
3. A one repetition maximal (1RM) effort of a weighted squat will be tested in the Plachy Hall weight room.
4. You will then be asked to perform five swings using a provided fastpitch softball bat with maximal effort. All participants will use the same bat. Bat swing velocity will be measured using a BatMaxx 500, vertical computerized photosensing timer.

Training Program:

The eight (8) week training program will be performed in the Plachy Hall weight room, under the supervision of Danniell Consonero (Primary Researcher) and Matt Gersick (Head

Strength and Conditioning Coach). Both additional medicine ball programs will be performed on the same day, prior to the regular, in-season lifting.

If you are randomly selected to participate in the control group, you will perform your regular, in-season lifting program 2 days a week, as well as additional medicine ball exercises. Exercises for the control group include: medicine ball push-up, chest pass with a partner, triceps extensions, and medicine ball press.

If you are randomly selected to participate in the experimental group, you will perform your regular, in-season lifting program 2 days a week, as well as a sport specific medicine ball training program. Exercises for the experimental group include: medicine ball Russian twist, hitters throw, underhand throw, twisting wood chop, standing backwards throw, standing figure 8, and 45° sit-up.

Written explanations and pictorial representations of each exercise that will be utilized in the study is attached separately.

BENEFITS

The potential benefits from this study include, but are not limited to: increased bat swing velocity and an increase in lower body and core strength and power production.

RISKS AND DISCOMFORTS

There are risks associated with the study that include the potential for injury, with any lifting program. Injuries most often occur with improper progression, improper loads, or poor technique. Every effort will be made to minimize the risk of injury throughout this study by performing the program under the supervision of certified professionals, teaching and encouraging proper form, and also by having the training programs written by individuals with years of experience with softball and resistance training. As a participant, to minimize your individual potential for injury, you will be asked to perform exercises to the best of your ability while being supervised by certified professionals. As a participant, you may also experience the discomfort of sore muscles, which is common with any new training program. In general, the risks associated with a resistance training program are less than that of playing the actual sport.

CONFIDENTIALITY

The researcher will not identify me by name in any reports using information obtained from this study. Any use of data and records will be subject to standard data use policies, which protect the anonymity of individuals. Data will be locked under a password protected computer for five years in which the researcher only has the password.

I understand that this study will be reviewed and approved by the Institutional Review Board (IRB) for Studies Involving Human Subjects at Adams State University. I understand that I can contact the Primary Researcher, and/or the Thesis Chair at any time with questions or concerns regarding the study.

Primary Researcher
DJ Consonero
consonerodj@grizzlies.adams.edu
719-320-0038

Thesis Chair
Dr. Tracey Robinson
tlrobins@adams.edu
719-587-7663

I hereby voluntarily give consent to engage in a medicine ball training program to see the effects on bat velocity. I understand that the training program will involve resistance training and the study is designed to gather information about the effects of an eight-week training program on bat velocity. I understand that during the eight weeks of training and testing I will be encouraged to work at maximum effort. I understand that I will be one of approximately 20 participants in the study. Lastly, I understand that I may choose to withdraw from the study, at any time, with no penalty. I have read the foregoing carefully and I understand its content. Any questions which may have occurred to me concerning this informed consent have been answered to my satisfaction.

______________________________ ____________
Participant's Printed Name Date

____
Participant's Signature

______________________________ ____________
Researcher's Signature Date

ADAMS STATE COLLEGE
INSTITUTIONAL REVIEW BOARD
Approved on: 1-9-15
Expires on: 1-9-16

Appendix B: Questionnaire

Please answer all to the best of your knowledge:

1. Age:
2. Eligibility Year:
3. Do you swing left handed or right handed?
4. Do you swing both left handed and right handed? YES / NO
5. How many years have you participated in fastpitch softball (years):
6. Position that you play currently (please list all if more than one):
7. Usual spot in the batting lineup for a game:
8. How many hours a week do you spend at hitting practice total:
9. Do you hit on your own outside of official team practice? YES / NO

   If YES, how many extra hours a week?
10. Do you take part in additional exercise outside of your sport or the regular training you are required to participate in? (For example, extra weights, running on your own, etc.)

    YES / NO

    If YES, what do you do and how many hours a week for each activity?

Appendix C: In-Season Strength and Conditioning Program

The following training program was developed by the Head Strength and Conditioning coach at Adams State University for the ASU Women's Softball in-season training schedule.

*ROM- range of motion
**BW- body weight
***AMAP- as much weight as possible

Week 1	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	5	ROM*
	Dumbbell Jump	5	5	Explosive
	Dumbbell Incline Press	3	8	Control
	Supine Medicine Ball Throw	3	6-8	Explosive
	Chin-up	3	8-10	BW**
	Dumbbell RDL	3	6-8	Heavy
	Medicine Ball Hitters Throw	3	8per	Explosive
Day 2	Trap Bar Jump	5	5	Explosive
	Trap Bar Deadlift	5	5	ROM*
	Dumbbell Power Step-Up	3	6-8per	Explosive
	Bench Press	5	5	ROM*
	Dumbbell 1 Arm Row	4	8-10per	Heavy
	Side Lying Extensions	4	10-12per	Control
	Seated Medicine Ball Side Throw	3	8per	Explosive

Week 2	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	4	ROM*
	Dumbbell Jump	5	5	Explosive
	Dumbbell Incline Press	3	8	Control
	Supine Medicine Ball Throw	3	6-8	Explosive
	Chin-up	3	8-10	BW**
	Dumbbell RDL	3	6-8	Heavy
	Medicine Ball Hitters Throw	3	8per	Explosive
Day 2	Trap Bar Jump	5	4	Explosive
	Trap Bar Deadlift	5	4	ROM*
	Dumbbell Power Step-Up	3	6-8per	Explosive
	Bench Press	5	4	ROM*
	Dumbbell 1 Arm Row	4	8-10per	Heavy
	Side Lying Extensions	4	10-12per	Control
	Seated Medicine Ball Side Throw	3	8per	Explosive

Week 3	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	3	ROM*
	Dumbbell Jump	5	5	Explosive
	Dumbbell Incline Press	3	6	Control
	Supine Medicine Ball Throw	3	4-6	Explosive
	Chin-up	3	6-8	BW**
	Dumbbell RDL	3	4-6	Heavy
	Medicine Ball Hitters Throw	3	8per	Explosive
Day 2	Trap Bar Jump	5	3	Explosive
	Trap Bar Deadlift	5	3	ROM*
	Dumbbell Power Step-Up	3	4-6per	Explosive
	Bench Press	5	3	ROM*
	Dumbbell 1 Arm Row	4	6-8per	Heavy
	Side Lying Extensions	4	10-12per	Control
	Seated Medicine Ball Side Throw	3	8per	Explosive

Week 4	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	6	2	ROM*
	Dumbbell Jump	6	2	Explosive
	Dumbbell Incline Press	3	6	Control
	Supine Medicine Ball Throw	3	4-6	Explosive
	Chin-up	3	6-8	BW**
	Dumbbell RDL	3	4-6	Heavy
	Medicine Ball Hitters Throw	3	8per	Explosive
Day 2	Trap Bar Jump	6	2	Explosive
	Trap Bar Deadlift	6	2	ROM*
	Dumbbell Power Step-Up	3	4-6per	Explosive
	Bench Press	6	2	ROM*
	Dumbbell 1 Arm Row	4	6-8per	Heavy
	Side Lying Extensions	4	10-12per	Control
	Seated Medicine Ball Side Throw	3	8per	Explosive

Week 5	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	5	ROM*
	Depth Jump	5	3	Explosive
	Inverted Row	3	8	ROM*
	Chin-up	3	8-10	BW**
	Dumbbell 1 Arm Press	3	6-8per	AMAP***
	P/C Attack	3	6-8per	ROM
	Kneeling Hitters Throw	3	8per	Explosive
Day 2	Barbell Complex	2	8-10	Moderate
	Dumbbell Step Back Lunge	3	6-8per	Heavy
	Dumbbell RDL	3	6-8	ROM*
	G/H Raise	2	12	ROM*
	Side Plank	2	30s	BW**

Week 6	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	4	ROM*
	Depth Jump	5	3	Explosive
	Inverted Row	3	8	ROM*
	Chin-up	3	8-10	BW**
	Dumbbell 1 Arm Press	3	6-8per	AMAP***
	P/C Attack	3	6-8per	ROM
	Kneeling Hitters Throw	3	8per	Explosive
Day 2	Barbell Complex	2	8-10	Moderate
	Dumbbell Step Back Lunge	3	6-8per	Heavy
	Dumbbell RDL	3	6-8	ROM*
	G/H Raise	2	12	ROM*
	Side Plank	2	40s	BW**

Week 7	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	5	3	ROM*
	Depth Jump	5	3	Explosive
	Inverted Row	3	8	ROM*
	Chin-up	3	6-8	BW**
	Dumbbell 1 Arm Press	3	4-6per	AMAP***
	P/C Attack	3	4-6per	ROM
	Kneeling Hitters Throw	3	8per	Explosive
Day 2	Barbell Complex	2	6-8	Moderate
	Dumbbell Step Back Lunge	3	4-6per	Heavy
	Dumbbell RDL	3	6-8	ROM*
	G/H Raise	2	12	ROM*
	Side Plank	2	40s	BW**

Week 8	Exercises	Sets	Reps	Emphasis
Day 1	Back Squat	6	2	ROM*
	Depth Jump	5	3	Explosive
	Inverted Row	3	8	ROM*
	Chin-up	3	6-8	BW**
	Dumbbell 1 Arm Press	3	4-6per	AMAP***
	P/C Attack	3	4-6per	ROM
	Kneeling Hitters Throw	3	8per	Explosive
Day 2	Barbell Complex	2	6-8	Moderate
	Dumbbell Step Back Lunge	3	4-6per	Heavy
	Dumbbell RDL	3	6-8	ROM*
	G/H Raise	2	12	ROM*
	Side Plank	2	40s	BW**

Appendix D: 8-week Experimental Training Program

The following exercises were performed in the order listed in the training program. All sets and repetitions of the exercises were completed before continuing on to the following exercise.

Week 1	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	2	8per	12lbs
	Hitters Throw (Right side)	2	8	12lbs
	Hitters Throw (Left side)	2	8	12lbs
	Underhand Throw	2	8	12lbs
Day 2	Twisting wood chop	2	8per	12lbs
	Standing Backwards Throw	2	8	12lbs
	Figure Eight with Partner	2	8per	12lbs
	45° Sit-up	2	8	12lbs

Week 2	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	2	10per	12lbs
	Hitters Throw (Right side)	2	10	12lbs
	Hitters Throw (Left side)	2	10	12lbs
	Underhand Throw	2	10	12lbs
Day 2	Twisting wood chop	2	10per	12lbs
	Standing Backwards Throw	2	10	12lbs
	Figure Eight with Partner	2	10per	12lbs
	45° Sit-up	2	10	12lbs

Week 3	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	2	10per	12lbs
	Hitters Throw (Right side)	2	10	12lbs
	Hitters Throw (Left side)	2	10	12lbs
	Underhand Throw	2	10	12lbs
Day 2	Twisting wood chop	2	10per	12lbs
	Standing Backwards Throw	2	10	12lbs
	Figure Eight with Partner	2	10per	12lbs
	45° Sit-up	2	10	12lbs

Week 4	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	2	10per	16lbs
	Hitters Throw (Right side)	2	10	12lbs
	Hitters Throw (Left side)	2	10	12lbs
	Underhand Throw	2	10	16lbs
Day 2	Twisting wood chop	2	10per	16lbs
	Standing Backwards Throw	2	10	16lbs
	Figure Eight with Partner	2	10per	16lbs
	45° Sit-up	2	10	16lbs

Week 5	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	3	10per	16lbs
	Hitters Throw (Right side)	3	10	12lbs
	Hitters Throw (Left side)	3	10	12lbs
	Underhand Throw	3	10	16lbs
Day 2	Twisting wood chop	3	10per	16lbs
	Standing Backwards Throw	3	10	16lbs
	Figure Eight with Partner	3	10per	16lbs
	45° Sit-up	3	10	16lbs

Week 6	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	3	10per	16lbs
	Hitters Throw (Right side)	3	10	16lbs
	Hitters Throw (Left side)	3	10	16lbs
	Underhand Throw	3	10	16lbs
Day 2	Twisting wood chop	3	10per	16lbs
	Standing Backwards Throw	3	10	16lbs
	Figure Eight with Partner	3	10per	16lbs
	45° Sit-up	3	10	16lbs

Week 7	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	3	10per	20lbs
	Hitters Throw (Right side)	3	10	16lbs
	Hitters Throw (Left side)	3	10	16lbs
	Underhand Throw	3	10	20lbs
Day 2	Twisting wood chop	3	10per	20lbs
	Standing Backwards Throw	3	10	20lbs
	Figure Eight with Partner	3	10per	20lbs
	45° Sit-up	3	10	20lbs

Week 8	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Russian Twist	3	10per	20lbs
	Hitters Throw (Right side)	3	10	16lbs
	Hitters Throw (Left side)	3	10	16lbs
	Underhand Throw	3	10	20lbs
Day 2	Twisting wood chop	3	10per	20lbs
	Standing Backwards Throw	3	10	20lbs
	Figure Eight with Partner	3	10per	20lbs
	45° Sit-up	3	10	20lbs

Appendix E: 8-week Control Training Program

The following exercises were performed in the order listed in the training program. All sets and repetitions of the exercises were completed before continuing on to the following exercise.

Week 1	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	2	8	12lbs
	Medicine Ball Push-Up (Left Side)	2	8	12lbs
	Chest Pass With Partner	2	8	12lbs
Day 2	Triceps Extension	2	8	12lbs
	Medicine Ball Press	2	8	12lbs

Week 2	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	2	10	12lbs
	Medicine Ball Push-Up (Left Side)	2	10	12lbs
	Chest Pass With Partner	2	10	12lbs
Day 2	Triceps Extension	2	10	12lbs
	Medicine Ball Press	2	10	12lbs

Week 3	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	2	10	12lbs
	Medicine Ball Push-Up (Left Side)	2	10	12lbs
	Chest Pass With Partner	2	10	12lbs
Day 2	Triceps Extension	2	10	12lbs
	Medicine Ball Press	2	10	12lbs

Week 4	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	2	10	12lbs
	Medicine Ball Push-Up (Left Side)	2	10	12lbs
	Chest Pass With Partner	2	10	16lbs
Day 2	Triceps Extension	2	10	16lbs
	Medicine Ball Press	2	10	16lbs

Week 5	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	3	10	12lbs
	Medicine Ball Push-Up (Left Side)	3	10	12lbs
	Chest Pass With Partner	3	10	16lbs
Day 2	Triceps Extension	3	10	16lbs
	Medicine Ball Press	3	10	16lbs

Week 6	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	3	10	12lbs
	Medicine Ball Push-Up (Left Side)	3	10	12lbs
	Chest Pass With Partner	3	10	16lbs
Day 2	Triceps Extension	3	10	16lbs
	Medicine Ball Press	3	10	16lbs

Week 7	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	3	10	12lbs
	Medicine Ball Push-Up (Left Side)	3	10	12lbs
	Chest Pass With Partner	3	10	20lbs
Day 2	Triceps Extension	3	10	20lbs
	Medicine Ball Press	3	10	20lbs

Week 8	Exercise	Sets	Reps	Weight
Day 1	Medicine Ball Push-Up (Right Side)	3	10	12lbs
	Medicine Ball Push-Up (Left Side)	3	10	12lbs
	Chest Pass With Partner	3	10	20lbs
Day 2	Triceps Extension	3	10	20lbs
	Medicine Ball Press	3	10	20lbs

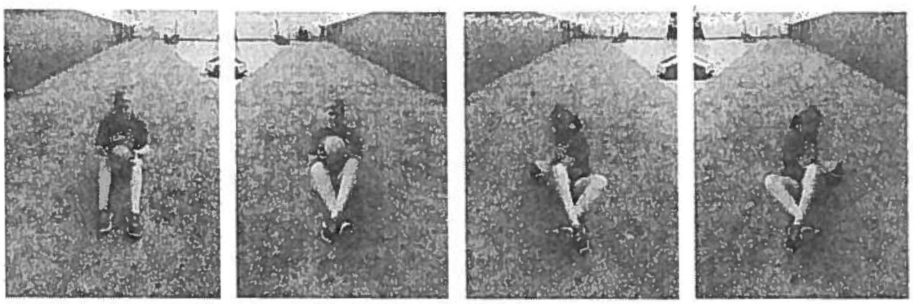
Appendix F: Warm-up Protocol

All exercises were performed once and then followed by a second set. One minute of rest was allowed between each set.

Exercise	Rep	Set
Body Weight Squat	15	2
Lunges (right leg)	10	2
Lunges (left leg)	10	2
Large Arm Circles (forward)	15	2
Large Arm Circles (backward)	15	2
Trunk Rotations	20	2

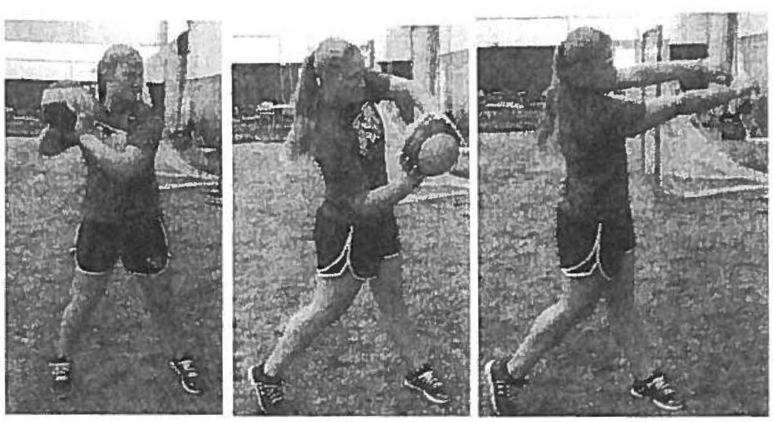
Appendix G: Exercises for Experimental Group

Medicine Ball Russian Twist



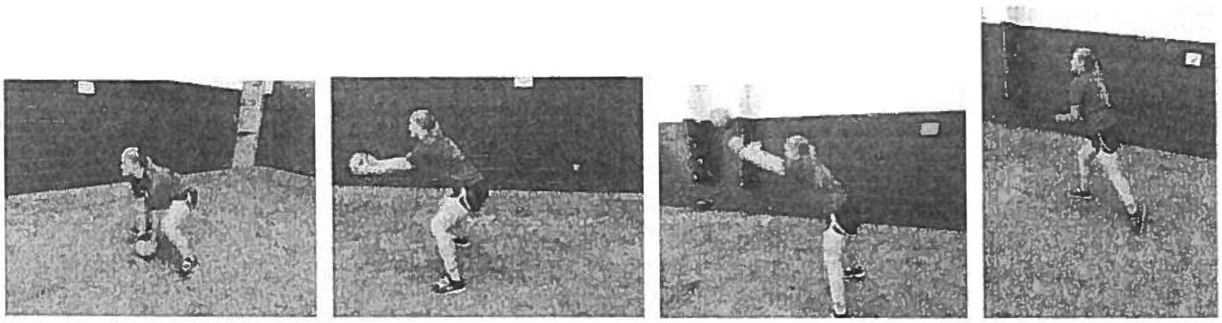
Participants sit on the floor holding the medicine ball in both hands. Participants are instructed to find their center of balance and then raise their feet slightly off the floor. They then hold the medicine ball out in front with straight arms. Participants are then be instructed to twist the torso to the left and then to the right side, reaching and planting the medicine ball on the floor of each side.

Hitters Throw



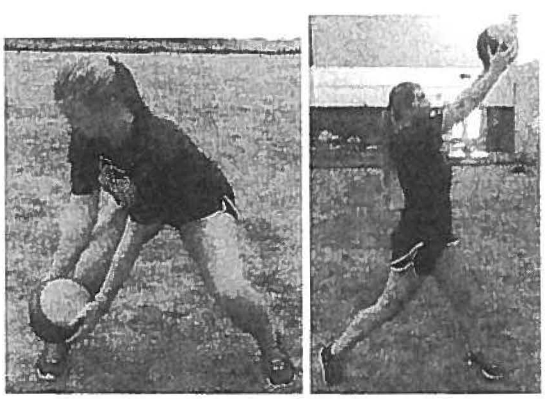
The exercise of the hitter's throw is where the participant stands in her normal batting stance with the medicine ball held at shoulder level (where the bat would be) with both hands, then throws the ball forward with explosive rotational effort. The participants is instructed to throw the ball at a wall and to pick out a spot on the wall and hit that spot every time and to be as explosive as possible. This exercise is to be done on both the left and right side.

Underhand Throw



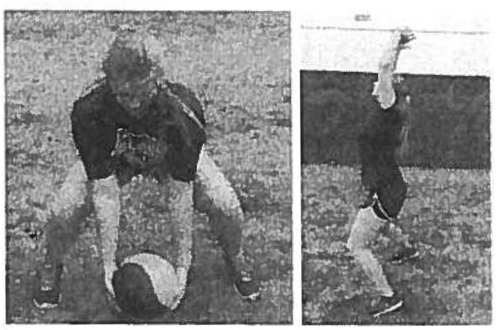
The participant stands with feet slightly apart, and faces the direction to which the ball is to be thrown. The ball is held in both hands between the legs, with the arms extended forward and downward. The hands are placed behind and under the ball. Using the legs, back and arms to assist, the ball is then thrown vigorously forward as far as possible. The subject is permitted to fall forward after the ball is released, and is in fact encouraged to do so to maximize the distance of the throw.

Twisting Wood Chop



The twisting wood chop is performed by the participant while holding a medicine ball and standing tall with their legs straight, feet hip-width apart and keeping the lower body planted, they twist from the waist toward the left and extend the arms overhead and toward the left side of the head. It is important the participants keep their arms straight and feet planted. Then twisting with the torso toward the right and lowering their arms diagonally across the body and down toward their right foot, bending both knees and pivoting the left foot. This exercise is performed for both left and right sides of the body. Participants should pull their abdominals in tight to protect their back while twisting side to side.

Standing Backwards Throw

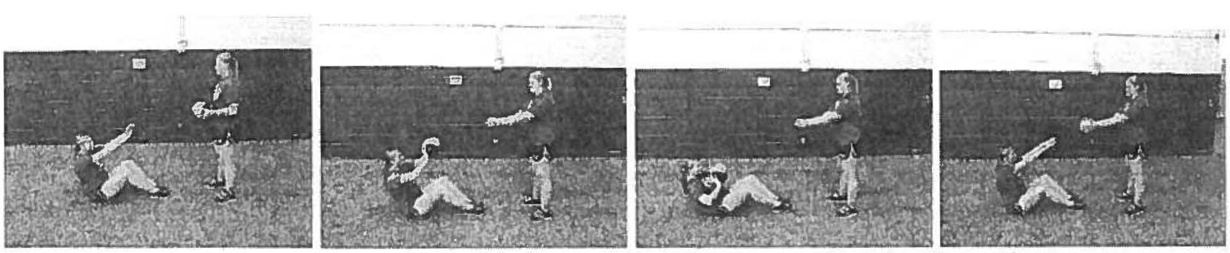


The standing backwards throw is also an explosive exercise that was used. This exercise is performed by holding the medicine ball above the head with both arms extended and in one continuous motion the participant lowers their body to a parallel squat position and then explosively extends their arms and legs while releasing the medicine ball behind their head into the air. The objective of the participant to throw the ball for distance, as far back as they can throw the medicine ball.

Standing Figure 8

This exercise is done in pairs. The participants are paired up according to similar heights. They then perform the standing figure 8 which is an exercise in which 2 participants stand back-to-back and rotate passing the medicine ball to each other. This exercise is to be completed in one constant direction and then the direction is reversed. The participants are instructed to perform this exercise as quickly as possible. Each pair will stayed together for the entire eight week program.

45° Sit-up



This exercise is also done in pairs. Participants sit on the ground with the trunk at an approximately 45° angle. The partner is to stand in front with the medicine ball. The partner throws the ball to the participant sitting on the ground. Once the ball is thrown, the participant then catches the ball using both arms, allow for minimal trunk extension, and immediately return the ball to the partner. The force used to return the ball to the partner should come predominately from the abdominal muscles.

Appendix H: Exercises for Control Group

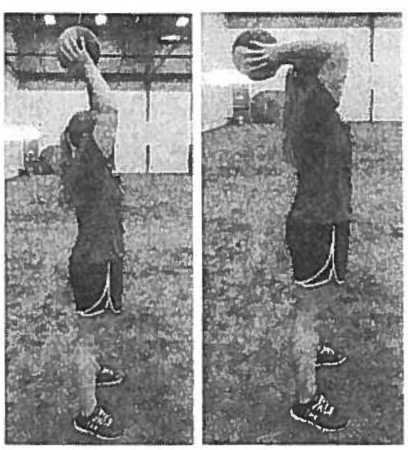
Medicine Ball Push-Up

Participants kneeled before the medicine ball. They then placed the left hand on top of ball and right hand on floor, slightly wider than shoulder width away. Participants positioned their upper body above both hands with their right arm straight and left arm bent with hand on ball. Then participants straightened their body with forefeet back away from ball on floor, shoulder width apart. Participants then lowered their body until slight stretch was felt in the shoulder or chest and push body back up. As the right arm straightens and raises above floor, they rolled the ball under right hand with the left hand. Landing with the right hand on ball while quickly placing left hand on floor, slightly wider than shoulder width. Participants repeated the movement with ball under right hand. The exercise was continued by alternating between sides.

Chest Pass with Partner

Participants began facing their partner holding the medicine ball at torso level with both hands. They then pulled the ball to chest level, and reversed the motion by extending through the elbows throwing the medicine ball to their partner. The partner then caught the ball, and returned the ball by throwing it back using the same steps. Participants were instructed to receive the throw with both hands at chest height.

Triceps Extension



Triceps extensions were done using a medicine ball. Participants were instructed to stand and hold the medicine ball in both hands with the arms extended, with their arms next to their ears. They then bent the elbows, lowering the ball behind the head until the elbows were at a 90 degree angle. Participants then fully extended their arms to complete the repetition.

Medicine Ball Press

Participants were instructed to lie on the ground with their back flat and their knees bent. They then held the medicine ball with their arms extended over the chest. They were then instructed to lower the ball to the chest and drive the ball straight up by extending the arms.

Appendix I: Data Collection Form

Data Form

Name/I.D. #: ______________________________ Age: _______ Class: _________

Height: ________ft. Weight: _________lbs.

Skinfold Measurements:

Pre-Test: _________ date

Chest: __________mm

Axilla: __________mm

Triceps: __________mm

Subscapula: __________mm

Suprailiac: __________mm

Abdomen: __________mm

Thigh: __________mm

% Body Fat: __________

LBM: __________

Fat Mass: __________

Post-Test: _________ date

Chest: ___________mm

Axilla: ___________mm

Triceps: ___________mm

Subscapula: ___________mm

Suprailiac: ___________mm

Abdomen: ___________mm

Thigh: ___________mm

% Body Fat: ___________mm

LBM: ___________

Fat Mass: ___________

1RM Squat:

Pre-Test: __________date

_______________lbs.

1RM Squat:

Post-Test: _________date

_______________lbs.

Bat Swing Velocity:

Pre-Test: _______ date

Swing	Velocity (mph)
1.	
2	
3.	
4.	
5.	
Average:	
Peak:	

Post-Test: _______ date

Swing	Velocity (mph)
1.	
2.	
3.	
4.	
5.	
Average:	
Peak:	

Appendix J: SPSS Output File

Experimental Group Descriptive Statistics

Descriptive Statistics[a]

	N	Mean	Std. Deviation
Pre_Weight_lbs	8	143.200	25.3199
Post_Weight_lbs	8	142.550	22.7774
Pre_Body_Fat	8	17.737	2.3736
Post_Body_Fat	8	18.213	2.2325
Pre_LBM	8	117.475	18.8138
Post_LBM	8	116.313	16.5975
Pre_Fat_Mass	8	25.713	7.3293
Post_Fat_Mass	8	26.237	6.8933
Pre_1RM_Squat_lbs	8	190.00	31.168
Post_1RM_Squat_lbs	8	212.50	24.928
Pre_Avg_Swing_Vel_mph	8	48.1450	8.51004
Post_Avg_Swing_Vel_mph	8	55.6138	6.41231
Pre_Peak_Swing_Vel_mph	8	57.738	9.0491
Post_Peak_Swing_Vel_mph	8	60.363	7.6212
Valid N (listwise)	8		

Training Group Descriptive Statistics

Descriptive Statistics

	N	Mean	Std. Deviation
Pre_Weight_lbs	16	146.500	24.0932
Post_Weight_lbs	16	145.256	21.9270
Pre_Body_Fat	16	17.900	2.2145
Post_Body_Fat	16	18.181	2.1075
Pre_LBM	16	119.925	17.6098
Post_LBM	16	118.525	15.7450
Pre_Fat_Mass	16	26.562	7.0703
Post_Fat_Mass	16	26.731	6.6413
Pre_1RM_Squat_lbs	16	191.87	26.260
Post_1RM_Squat_lbs	16	213.75	37.572
Pre_Avg_Swing_Vel_mph	16	49.0313	9.33741
Post_Avg_Swing_Vel_mph	16	55.3306	11.71835
Pre_Peak_Swing_Vel_mph	16	58.262	10.0749
Post_Peak_Swing_Vel_mph	16	59.256	12.3773
Valid N (listwise)	16		

Participants Descriptive Statistics

	N	Mean	Std. Deviation
Height_cm	16	165.7638	6.68342
Valid N (listwise)	16		

Average Bat Swing Velocity Results

Within-Subjects Factors

Measure : Average Bat Swing Velocity

Time_Of_Test	Dependent Variable
1	Pre_Avg_Swing_Vel_mph
2	Post_Avg_Swing_Vel_mph

Between-Subjects Factors

		Value Label	N
Training_Group	1	Experimental Group	8
	2	Control Group	8

Descriptive Statistics

	Training_Group	Mean	Std. Deviation	N
Pre_Avg_Swing_Vel_mph	Experimental Group	48.1450	8.51004	8
	Control Group	49.9175	10.61196	8
	Total	49.0313	9.33741	16
Post_Avg_Swing_Vel_mph	Experimental Group	55.6138	6.41231	8
	Control Group	55.0475	15.90457	8
	Total	55.3306	11.71835	16

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time_Of_Test	Pillai's Trace	.335	7.057[b]	1.000	14.000	.019
	Wilks' Lambda	.665	7.057[b]	1.000	14.000	.019
	Hotelling's Trace	.504	7.057[b]	1.000	14.000	.019
	Roy's Largest Root	.504	7.057[b]	1.000	14.000	.019
Time_Of_Test * Training_Group	Pillai's Trace	.017	.243[b]	1.000	14.000	.630
	Wilks' Lambda	.983	.243[b]	1.000	14.000	.630
	Hotelling's Trace	.017	.243[b]	1.000	14.000	.630
	Roy's Largest Root	.017	.243[b]	1.000	14.000	.630

a. Design: Intercept + Training_Group

Within Subjects Design: Time_Of_Test

b. Exact statistic

Mauchly's Test of Sphericity[a]

Measure: Average Bat Swing Velocity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time_Of_Test	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Training_Group

Within Subjects Design: Time_Of_Test

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Average Bat Swing Velocity

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time_Of_Test	Sphericity Assumed	317.457	1	317.457	7.057	.019
	Greenhouse-Geisser	317.457	1.000	317.457	7.057	.019
	Huynh-Feldt	317.457	1.000	317.457	7.057	.019
	Lower-bound	317.457	1.000	317.457	7.057	.019
Time_Of_Test * Training_Group	Sphericity Assumed	10.940	1	10.940	.243	.630
	Greenhouse-Geisser	10.940	1.000	10.940	.243	.630
	Huynh-Feldt	10.940	1.000	10.940	.243	.630
	Lower-bound	10.940	1.000	10.940	.243	.630
Error(Time_Of_Test)	Sphericity Assumed	629.807	14	44.986		
	Greenhouse-Geisser	629.807	14.000	44.986		
	Huynh-Feldt	629.807	14.000	44.986		
	Lower-bound	629.807	14.000	44.986		

Peak Swing Velocity

Within-Subjects Factors

Measure: Peak Swing Velocity

peak_velocity	Dependent Variable
1	Pre_Peak_Swing_Vel_mph
2	Post_Peak_Swing_Vel_mph

Between-Subjects Factors

		N
Training_Group	Control	8
	Experimental	8

Descriptive Statistics

	Training_Group	Mean	Std. Deviation	N
Pre_Peak_Swing_Vel_mph	Control	58.788	11.6186	8
	Experimental	57.738	9.0491	8
	Total	58.262	10.0749	16
Post_Peak_Swing_Vel_mph	Control	58.150	16.3525	8
	Experimental	60.363	7.6212	8
	Total	59.256	12.3773	16

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
peak_velocity	Pillai's Trace	.009	.124[b]	1.000	14.000	.730	.009	.124	.062
	Wilks' Lambda	.991	.124[b]	1.000	14.000	.730	.009	.124	.062
	Hotelling's Trace	.009	.124[b]	1.000	14.000	.730	.009	.124	.062
	Roy's Largest Root	.009	.124[b]	1.000	14.000	.730	.009	.124	.062
peak_velocity * Training_Group	Pillai's Trace	.023	.334[b]	1.000	14.000	.573	.023	.334	.084
	Wilks' Lambda	.977	.334[b]	1.000	14.000	.573	.023	.334	.084
	Hotelling's Trace	.024	.334[b]	1.000	14.000	.573	.023	.334	.084
	Roy's Largest Root	.024	.334[b]	1.000	14.000	.573	.023	.334	.084

a. Design: Intercept + Training_Group
Within Subjects Design: peak_velocity

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Peak Swing Velocity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
peak_velocity	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Training_Group
Within Subjects Design: peak_velocity

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Peak Swing Velocity

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
peak_velocity	Sphericity Assumed	7.900	1	7.900	.124	.730	.009	.124	.062
	Greenhouse-Geisser	7.900	1.000	7.900	.124	.730	.009	.124	.062
	Huynh-Feldt	7.900	1.000	7.900	.124	.730	.009	.124	.062
	Lower-bound	7.900	1.000	7.900	.124	.730	.009	.124	.062
peak_velocity * Training_Group	Sphericity Assumed	21.288	1	21.288	.334	.573	.023	.334	.084
	Greenhouse-Geisser	21.288	1.000	21.288	.334	.573	.023	.334	.084
	Huynh-Feldt	21.288	1.000	21.288	.334	.573	.023	.334	.084
	Lower-bound	21.288	1.000	21.288	.334	.573	.023	.334	.084
Error(peak_velocity)	Sphericity Assumed	892.937	14	63.781					
	Greenhouse-Geisser	892.937	14.000	63.781					
	Huynh-Feldt	892.937	14.000	63.781					
	Lower-bound	892.937	14.000	63.781					

a. Computed using alpha = .05

1RM Weighted Squat Results

Within-Subjects Factors

Measure: 1RM Weighted Squat

Time_of_test	Dependent Variable
1	Pre_1RM_Squat_lbs
2	Post_1RM_Squat_lbs

Between-Subjects Factors

		Value Label	N
Training_Group	1	Experimental Group	8
	2	Control Group	8

Descriptive Statistics

	Training_Group	Mean	Std. Deviation	N
Pre_1RM_Squat_lbs	Experimental Group	190.00	31.168	8
	Control Group	193.75	22.321	8
	Total	191.87	26.260	16
Post_1RM_Squat_lbs	Experimental Group	212.50	24.928	8
	Control Group	215.00	48.990	8
	Total	213.75	37.572	16

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time_of_test	Pillai's Trace	.423	10.269[b]	1.000	14.000	.006
	Wilks' Lambda	.577	10.269[b]	1.000	14.000	.006
	Hotelling's Trace	.734	10.269[b]	1.000	14.000	.006
	Roy's Largest Root	.734	10.269[b]	1.000	14.000	.006
Time_of_test * Training_Group	Pillai's Trace	.001	.008[b]	1.000	14.000	.928
	Wilks' Lambda	.999	.008[b]	1.000	14.000	.928
	Hotelling's Trace	.001	.008[b]	1.000	14.000	.928
	Roy's Largest Root	.001	.008[b]	1.000	14.000	.928

a. Design: Intercept + Training_Group
Within Subjects Design: Time_of_test

b. Exact statistic

Mauchly's Test of Sphericity[a]

Measure: 1RM Weighted Squat

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time_of_test	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Training_Group
Within Subjects Design: Time_of_test

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: 1RM Weighted Squat

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time_of_test	Sphericity Assumed	3828.125	1	3828.125	10.269	.006
	Greenhouse-Geisser	3828.125	1.000	3828.125	10.269	.006
	Huynh-Feldt	3828.125	1.000	3828.125	10.269	.006
	Lower-bound	3828.125	1.000	3828.125	10.269	.006
Time_of_test * Training_Group	Sphericity Assumed	3.125	1	3.125	.008	.928
	Greenhouse-Geisser	3.125	1.000	3.125	.008	.928
	Huynh-Feldt	3.125	1.000	3.125	.008	.928
	Lower-bound	3.125	1.000	3.125	.008	.928
Error(Time_of_test)	Sphericity Assumed	5218.750	14	372.768		
	Greenhouse-Geisser	5218.750	14.000	372.768		
	Huynh-Feldt	5218.750	14.000	372.768		
	Lower-bound	5218.750	14.000	372.768		

Lean Body Mass Results

Within-Subjects Factors

Measure: LBM

Time_of_test	Dependent Variable
1	Pre_LBM
2	Post_LBM

Between-Subjects Factors

		Value Label	N
Training_Group	1	Experimental Group	8
	2	Control Group	8

Descriptive Statistics

	Training_Group	Mean	Std. Deviation	N
Pre_LBM	Experimental Group	117.475	18.8138	8
	Control Group	122.375	17.2287	8
	Total	119.925	17.6098	16
Post_LBM	Experimental Group	116.313	16.5975	8
	Control Group	120.738	15.6385	8
	Total	118.525	15.7450	16

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time_of_test	Pillai's Trace	.166	2.793[b]	1.000	14.000	.117
	Wilks' Lambda	.834	2.793[b]	1.000	14.000	.117
	Hotelling's Trace	.199	2.793[b]	1.000	14.000	.117
	Roy's Largest Root	.199	2.793[b]	1.000	14.000	.117
Time_of_test * Training_Group	Pillai's Trace	.006	.080[b]	1.000	14.000	.781
	Wilks' Lambda	.994	.080[b]	1.000	14.000	.781
	Hotelling's Trace	.006	.080[b]	1.000	14.000	.781
	Roy's Largest Root	.006	.080[b]	1.000	14.000	.781

a. Design: Intercept + Training_Group

Within Subjects Design: Time_of_test

b. Exact statistic

Mauchly's Test of Sphericity[a]

Measure: LBM

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time_of_test	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Training_Group
 Within Subjects Design: Time_of_test

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: LBM

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time_of_test	Sphericity Assumed	15.680	1	15.680	2.793	.117
	Greenhouse-Geisser	15.680	1.000	15.680	2.793	.117
	Huynh-Feldt	15.680	1.000	15.680	2.793	.117
	Lower-bound	15.680	1.000	15.680	2.793	.117
Time_of_test * Training_Group	Sphericity Assumed	.451	1	.451	.080	.781
	Greenhouse-Geisser	.451	1.000	.451	.080	.781
	Huynh-Feldt	.451	1.000	.451	.080	.781
	Lower-bound	.451	1.000	.451	.080	.781
Error(Time_of_test)	Sphericity Assumed	78.599	14	5.614		
	Greenhouse-Geisser	78.599	14.000	5.614		
	Huynh-Feldt	78.599	14.000	5.614		
	Lower-bound	78.599	14.000	5.614		

Body Fat Percentages Results

Within-Subjects Factors

Measure: % Body Fat

Time_of_test	Dependent Variable
1	Pre_Body_Fat
2	Post_Body_Fat

Between-Subjects Factors

		Value Label	N
Training_Group	1	Experimental Group	8
	2	Control Group	8

Descriptive Statistics

	Training_Group	Mean	Std. Deviation	N
Pre_Body_Fat	Experimental Group	17.737	2.3736	8
	Control Group	18.063	2.1941	8
	Total	17.900	2.2145	16
Post_Body_Fat	Experimental Group	18.213	2.2325	8
	Control Group	18.150	2.1287	8
	Total	18.181	2.1075	16

Mauchly's Test of Sphericity[a]

Measure: % Body Fat

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time_of_test	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Training_Group

Within Subjects Design: Time_of_test

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time_of_test	Pillai's Trace	.119	1.888[b]	1.000	14.000	.191
	Wilks' Lambda	.881	1.888[b]	1.000	14.000	.191
	Hotelling's Trace	.135	1.888[b]	1.000	14.000	.191
	Roy's Largest Root	.135	1.888[b]	1.000	14.000	.191
Time_of_test * Training_Group	Pillai's Trace	.060	.896[b]	1.000	14.000	.360
	Wilks' Lambda	.940	.896[b]	1.000	14.000	.360
	Hotelling's Trace	.064	.896[b]	1.000	14.000	.360
	Roy's Largest Root	.064	.896[b]	1.000	14.000	.360

a. Design: Intercept + Training_Group

Within Subjects Design: Time_of_test

b. Exact statistic

Measure: % Body Fat

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time_of_test	Sphericity Assumed	.633	1	.633	1.888	.191
	Greenhouse-Geisser	.633	1.000	.633	1.888	.191
	Huynh-Feldt	.633	1.000	.633	1.888	.191
	Lower-bound	.633	1.000	.633	1.888	.191
Time_of_test * Training_Group	Sphericity Assumed	.300	1	.300	.896	.360
	Greenhouse-Geisser	.300	1.000	.300	.896	.360
	Huynh-Feldt	.300	1.000	.300	.896	.360
	Lower-bound	.300	1.000	.300	.896	.360
Error(Time_of_test)	Sphericity Assumed	4.692	14	.335		
	Greenhouse-Geisser	4.692	14.000	.335		
	Huynh-Feldt	4.692	14.000	.335		
	Lower-bound	4.692	14.000	.335		

Correlations of Post Average Bat Swing Velocity and Post 1RM Squat

Correlations

		Post_Avg_Swing_Vel_mph	Post_1RM_Squat_lbs
Post_Avg_Swing_Vel_mph	Pearson Correlation	1	.340
	Sig. (2-tailed)		.198
	N	16	16
Post_1RM_Squat_lbs	Pearson Correlation	.340	1
	Sig. (2-tailed)	.198	
	N	16	16